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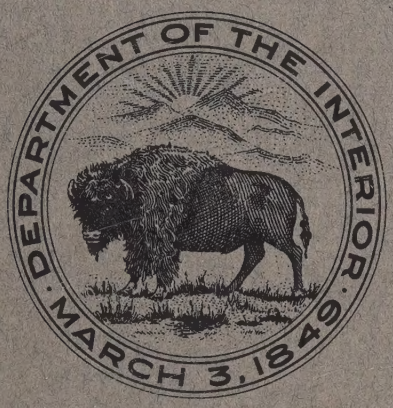
Vol. 13 No. 2



APRIL 1951

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

THE PROGRESSIVE FISH-CULTURIST

Issued by

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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THE EFFECT OF RETARDATION OF THE INITIAL FEEDING ON THE GROWTH AND SURVIVAL OF SALMON FINGERLINGS

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EXPERIMENTS were conducted at the Leavenworth Laboratory and the Coleman (Anderson, California) Laboratory of the Fish and Wildlife Service during 1949 to determine the effect of the retardation of the initial feeding on the growth and survival of salmon fingerlings.

The extreme differences of opinion among fish-culturists as to the proper time to begin feeding salmon and trout indicated the necessity for experimentation on this particular phase of fish culture. Many recommendations were based on doubtful theories. Other recommendations represented various types of experiments which were designed solely for the determination of the earliest possible stage at which fish would take food. It was apparent that there was a need for more emphasis on the subsequent rate of growth and percentage of survival of the fish as an index to the optimum stage for initial feeding.

The U. S. Commission of Fish and Fisheries (1897), followed by Henshall (1904), Hein (1906), Titcomb (1908), Bower (1911), Schaeperclaus (1933), and Brown and Buck (1939) agree that feeding of salmon and trout should be begun as soon as the fish are capable of swimming up, free of the bottom, thus entering the so-called "swim-up" stage. According to Leach (1924), the time to begin feeding trout varies between species, so that brook trout should be fed as soon as they are free swimming, but the time to feed rainbow fry is when the umbilical sac is absorbed. Atkins (1905) found a greater mortality in brook trout fed early than in those remaining unfed for 5 days. He reported that fasting beyond the fifth day increased the rate of mortality in brook trout and lake trout, but not in silver salmon. He disapproved of the practice of very early feeding even though the fry were capable of taking food. Because of these varied and contradictory recommendations, both the Leavenworth Laboratory and the Coleman Laboratory studied the problem. The work at Leavenworth was conducted with blueback salmon (Oncorhynchus nerka), and that at Coleman was done with fall chinook salmon (O. tschawytscha).

The experiments indicate that the availability of an adequate supply of food at the critical time when the fish first feel the desire to feed contributes significantly to the growth of both blueback and chinook salmon fingerlings. When salmon are placed in troughs shortly before the earliest ones will swim up, and are fed as soon as they are free swimming, not only is the growth rate accelerated

---

1/ Since the completion of this work, Mr. Johnson has been assigned to Dorena Dam, Oregon.--The EDITORS.

but the utilization of the food is more efficient in comparison with that of fish which remain unfed until the yolk sac has nearly or completely disappeared from view. Although no significant differences in mortality occur, the presence of large numbers of stunted, slow-growing, and pinheaded fish in the retarded groups offers further proof of the effects of prolonged retardation. It is entirely possible that the occurrence of such stunted stock--a condition which is commonly attributed to such things as defective eggs, faulty feeding practices, or poor diets--in some hatcheries may, in the majority of instances, be caused by a retardation of the time of initial feeding of the fish.

METHODS

In preparation for the experiment with blueback salmon at the Leavenworth Laboratory, 216,000 eyed eggs, all of which were from a single day's take, were selected and divided into 12 parts consisting of 18,000 eggs each. A displacement method of egg measurement (Burrows 1951) was used for the enumeration. Each part, destined to become an individual trough of fish, was retained as a separate unit throughout the remainder of the egg and subsequent fry stage. The experiment, which was conducted for a period of 20 weeks, involved four lots, each of which contained three troughs of fish. The letter B, indicating blueback salmon, was used with each lot number.

Lot B-1 was placed in troughs for feeding shortly before the first fish were able to rise free of support of the bottom. Lot B-2 was placed in troughs when approximately 25 percent of the fish on a floating tray were free-swimming, this being the stage normally in use at the stations on the Grand Coulee Project. The interval of 8 days, which occurred between Lot B-1 and Lot B-2, was used as the standard interval between Lots B-2 and B-3 and Lots B-3 and B-4; thus Lot B-3 was placed in troughs 16 days later than Lot B-1, and Lot B-4 was placed in troughs 24 days later than Lot B-1.

The fish were held in deep hatchery troughs (16 feet long and 16½ inches wide) that had an average water depth of 10 inches. The mean water temperature during the experiment was 44.3° F., the average biweekly temperatures progressing gradually from 42.79° F. at the beginning of the experiment to 45.07° F. at the end. The fish were closely observed during the stage in which they rose from the bottom, for it was desired to compare the four lots with regard to the time required for 100 percent swim-up and the time when feeding first occurred, as determined by observation.

For the first 4 weeks of the experiment, all fish were fed a starting diet consisting of equal parts of beef liver and hog liver. As it was then evident that the fish were feeding well, they were given a diet consisting of 22.2 percent each of beef liver, hog liver, and hog spleen, and 33.4 percent salmon viscera. This diet was used throughout the next 6 weeks of the experiment. Salt was added thereafter at the rate of 1 pound per 100 pounds of food to bind the diet, and the bound diet was fed for the remainder of the experiment.

The amount of food fed was determined by use of a feeding chart for blueback salmon, a chart based on fish size, total weight, and water temperature. Increases in the amount fed were made at biweekly intervals to conform with the gains in weight. The food was distributed by means of a standard hand ricer, its cup having 1/16-inch holes for the first 12 weeks of the experiment and 3/32-inch holes for the remaining 8 weeks, when the fish were larger and could take larger food particles. The fish were fed eight times daily during the first 12 weeks of the experiment and five times daily thereafter.

The fish in all troughs were weighed at biweekly intervals to determine gains in weight. The weighing technique used consisted of draining the fish of each trough for 15 seconds in the net and then putting the fish into the weighing container. Complete records were kept on mortalities in all troughs throughout the experiment.

The design of the experiment with fall chinook salmon at the Coleman Laboratory and the methods used were essentially the

same as those employed at the Leavenworth Laboratory, with a few minor changes. The 60,000 eyed eggs selected for this experiment from a single day's take were counted into 12 groups of 5,000 eggs each. Each group represented a trough of fish and three troughs constituted a lot, as in the Leavenworth experiment. To distinguish between the two experiments, the letter C, indicating chinook salmon, was used with the numbers of the lots in the Coleman experiment.

The mean water temperature during the experiment at Coleman was 54° F., the average daily temperatures progressing gradually from 49° to 61° F. The starting diet that was used at the Leavenworth Laboratory was fed at Coleman for the first 7½ weeks. The diet fed for the remaining period consisted of 19 percent each of beef liver and hog liver, 20 percent spleen, 30 percent salmon viscera, 10 percent fish meal, and 2 percent salt. A feeding chart, similar to that used with blueback salmon but adapted for use with chinook salmon, was used in determining the amount of food fed. As the requirement of food for chinook salmon, in terms of percentage of body weight, is approximately 2 percent below that of blueback salmon, the chinook received a proportionally smaller amount of food per day. Throughout the experiment, they were fed four times daily with a standard hand ricer. Feeding continued for 13 weeks.

The fish in Lot C-1 were placed in troughs for feeding 7 days earlier than the fish were usually fed at that station. Because many of the fish in this lot were free-swimming when first placed in the troughs and the vast majority of the fish were up by the second day, this lot corresponded most closely to Lot B-2 of the Leavenworth experiment. The fish in Lot C-2 were retarded for the 7-day interval. As the water temperatures at Coleman were considerably higher than those at Leavenworth, the rate of development of the chinook was more rapid. Lot C-2 of the Coleman experiment, therefore, was more nearly comparable to Lot B-3 at Leavenworth. Lot C-3, which was retarded for 14 days, corresponded to Lot B-4. Lot C-4, which was retarded for 21 days, had no counterpart in the Leavenworth experiment. These observations were confirmed by the average weight per fish in each lot at the time the fish were put out to feed. In the Leavenworth experiment, the average weights were progressively greater with each of the four lots. In the Coleman experiment, however, the increase in average weight ceased with Lot C-3 and the average weight per fish in Lot C-4 dropped well below those of the three other lots. The reduction in weight was an indication that the supply of yolk material had been reduced to the point that its utilization was no longer adequate for proper maintenance.

EXPERIMENTAL RESULTS

The results of these two experiments with blueback and chinook may be divided into two main parts. The first part is concerned with observation of the various lots during the swim-up stage. The second part deals with their total gains and mortalities for the duration of the entire experiment.

The differences in development and the effects of these differences on the rate of swim-up and first feeding were carefully observed. Figure 1 shows drawings of fish representative of the four lots at Leavenworth at the time of their placement in troughs. The variation in the amount of yolk absorption in each lot when the fish were first placed in troughs is apparent. Figure 2 shows the time of initial feeding and the effects of the retardation on the rate of swim-up of blueback salmon at the Leavenworth Laboratory.

The fish in Lot B-1 had extremely large yolk sacs. Although some mortality from smothering due to crowding was anticipated, none occurred; instead, the fish distributed themselves evenly over the bottom of the troughs. Ten days were required to reach 100 percent swim-up. These fish received their initial feeding on the third day, when approximately 2 percent were free-swimming. Some were observed taking food on the fourth day.

The fish in Lot B-2 still possessed quite large yolk sacs. On the eleventh day, 3 days after placement in troughs, the entire group was free-swimming. They

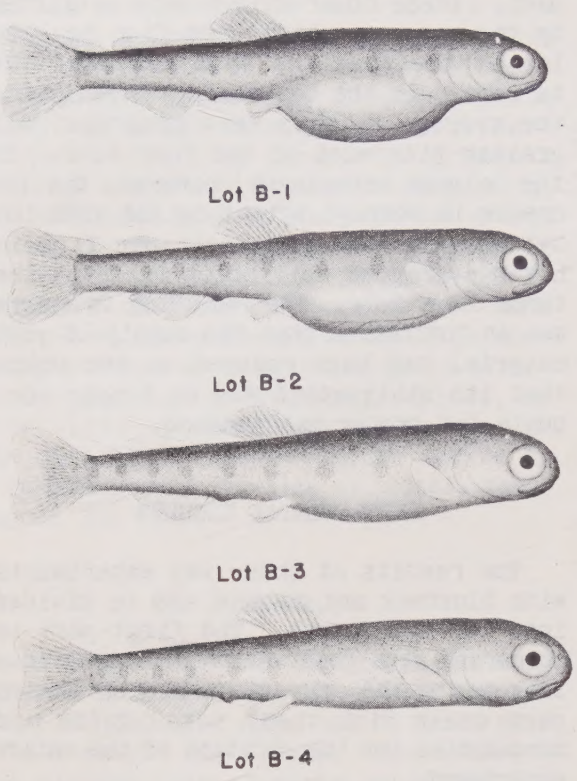

FIGURE 1.--Stage of development of blueback salmon representative of the four lots of fish at the time of first placement in troughs.

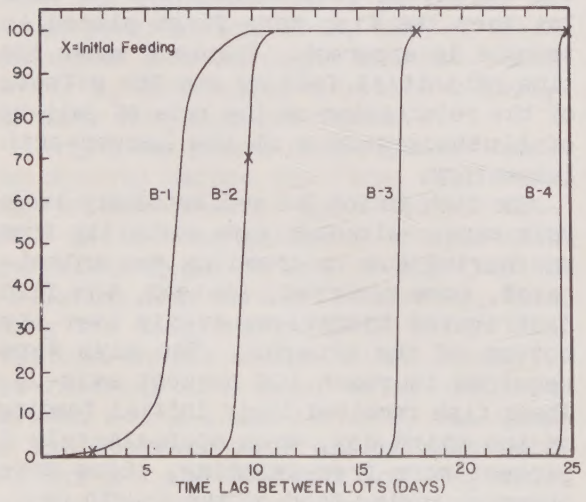

FIGURE 2.--The time of the initial feeding and the effect of retardation on the rate of swim-up of blueback salmon.

were given their initial feeding on the tenth day and were seen taking food the following day.

The fish in the third group (Lot B-3) had absorbed nearly all of their visible yolk sacs. As they required only 2 days for 100 percent swim-up, the fish were all free-swimming by the eighteenth day. When feeding was initiated on the eighteenth day, many were observed taking food immediately.

The fish in the last group (Lot B-4) were very thin. The yolk sacs had disappeared from view. When placed in the troughs, the fish swam up immediately. They were promptly fed and many were seen striking at the minute food particles.

It is interesting to note that the fish in Lot B-4 represent the stage of development which is recognized by many fish-culturists as the proper time to begin feeding. This concept undoubtedly is based upon the fact that observation of the immediate reaction of a group of fish to the new environment in the trough, rather than eventual growth and survival, has been used as the criterion for the selection of this particular stage of development. Thus the rapid rate of swim-up in Lot B-4 and the ease with which the fish adapted themselves to their new environment--in contrast with the extremely slow rate of swim-up and the corresponding lag in development of the fish in Lot B-1--might well appear to suggest that this period in development is the proper stage to begin feeding. On the contrary, the extremely slow rate of swim-up exhibited in Lot B-1 indicates that there is considerable variation in the rate of development among fish within a single day's egg take. As shown in figure 2, the process of swimming up began gradually in Lot B-1. The percentage steadily increased until during the sixth and seventh days the vast majority rose from the bottom. The portion remaining on the bottom then dwindled to nothing in the next 3 days. With food available from the third day on, the more advanced fish could feed at will from the time they first felt the desire to take food. The fish in Lot B-1 were receiving food 7 days before those in Lot B-2, 15 days before those in Lot B-3, and 22 days before those in Lot B-4.

Observation of the four groups of chinook salmon at the Coleman Laboratory revealed essentially the same results as at the Leavenworth Laboratory. As previously mentioned, the chinooks were further advanced in development when the experiment was started, for many of the fish in Lot C-1 were swimming up and the majority of those fish were free-swimming by the second day. Although the 7-day interval used with the four chinook lots might seem smaller than the 8-day interval used at Leavenworth, in terms of development the 7-day interval was the greater because of the warmer water temperatures at Coleman. The warmer temperatures effected a greater spread among the four lots, resulting in an extreme emaciation in the fish of Lot C-4. Their comparative gains and mortalities are the ultimate tests in the evaluation of these groups of fish. Figure 3 shows the average weight per fish in each lot at Leavenworth, plotted at biweekly periods. The effect of retardation was apparent at the time of the first weigh period (February 2), and the differences increased steadily as the experiment progressed. The increasingly greater conversion factors found in the retarded groups indicate not only that the gains were greater in the early fed groups but also that their food utilization was more efficient. Table 1 shows the comparative gains, conversions, and mortalities of the blueback salmon in the Leavenworth experiment.

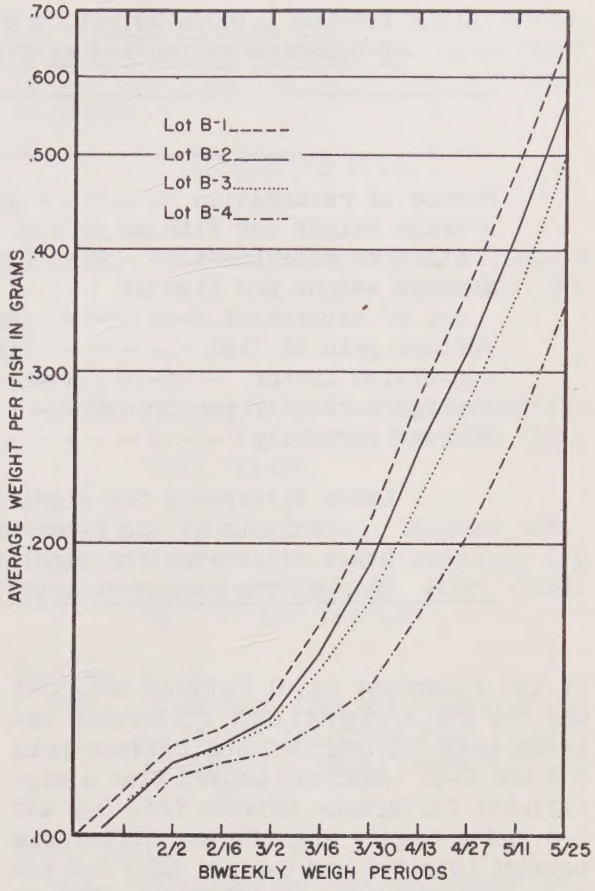

FIGURE 3.--The effect of retardation on the growth rate of blueback salmon.

The average mortality per trough in each of the four lots varied only slightly, but differences in mortality between troughs within the lots accounted for the large least difference required for significance. The numbers of stunted and pinheaded fish which could be observed varied proportionately with the amount of retardation of the initial feeding. In Lot B-1, very few could be seen; in Lot B-4, the great majority of the fish appeared to be stunted or pinheaded. This observation is confirmed by the differences between lots in the average weights of the fish.

Analysis of variance (Snedecor 1946) was made of the average weight of individual fish per trough (table 1). This analysis showed no significant difference at the 5-percent level between Lots B-1 and B-2 or between Lots B-2 and B-3 but a significant difference between Lots B-3 and B-4. The analysis showed also a significant difference between Lots B-1 and B-3 and a highly significant difference between Lots B-1 and B-4 and Lots B-2 and B-4. Similar analysis of individual trough mortalities showed no significant difference between lots or troughs.

The results of the Coleman experiment very nearly duplicated the results of the Leavenworth experiment. The differences in percent gain and mortality were, however, not quite so great. Table 2 shows the comparative gains and mortalities observed in that experiment.

An analysis of variance made of the average weight of individual fish per trough showed no significant difference

TABLE 1.--The gain in weight, conversion, and mortality of four lots of blueback salmon fed at different stages in development

	Lot			
	B-1	B-2	B-3	B-4
Period of retardation - - - - - (days)	0	8	16	24
Average weight per fish at start of experiment - - - - (grams)	0.100	0.102	0.109	0.110
Average weight per fish at end of experiment - - - - - (grams)	0.666	0.575	0.504	0.356
Percent gain of fish - - - - - (grams)	566	464	362	246
Conversion factor - - - - - - - - - -	4.66	4.92	5.31	7.50
Average mortality per trough - - - - -	1,747	1,752	1,709	2,199
Percent mortality - - - - - - - - - -	9.70	9.73	9.49	12.22

Least difference for significance between final average weights at the 5-percent level: 0.122 grams.
Least difference for significance between mortalities at the 5-percent level: 1,272 - 7.07 percent.

at the 5-percent level between Lots C-1 and C-2 but a significant difference between Lots C-2 and C-3 and between Lots C-3 and C-4. Analysis showed also a significant difference between Lots C-1 and C-3 and a highly significant difference between Lots C-1 and C-4 and Lots C-2 and C-4. The analysis of individual trough mortalities showed no significant difference between lots, thus confirming the similar analysis in the Leavenworth experiment.

The average weights of the fish at the conclusion of the experiments, as shown in tables 1 and 2, indicate two dissimilar patterns. In table 1 (prepared for the blueback salmon experiment), significant differences between adjacent lots occurred only in the last two groups. In contrast to this relationship, significance developed between the second and third lots in the chinook experiment (see table 2). These results are a further confirmation of the conclusions drawn

TABLE 2.--The gain in weight and mortality of four lots of chinook salmon fed at different stages in development

	Lot			
	C-1	C-2	C-3	C-4
Period of retardation - - - - - (days)	0	7	14	21
Average weight per fish at start of experiment - - - - (grams)	0.339	0.364	0.371	0.327
Average weight per fish at end of experiment - - - - - (grams)	2.38	2.39	2.11	1.81
Percent gain of fish - - - - - (grams)	602	556	469	454
Average mortality per trough - - - - -	361	308	382	711
Percent mortality - - - - - - - - - -	7.22	6.16	7.64	14.22

Least difference for significance between final average weights at the 5-percent level: 0.232 grams.
Least difference for significance between mortalities at the 5-percent level: 660 - 13.20 percent.

from the differences in initial average weights of the lots and the reactions of the fish when first placed in troughs to feed. It is obvious that the fish in the chinook experiment were retarded for approximately one period more than those of the blueback group. Lots B-1 and C-4 are, therefore, aberrant in that they are not duplicated in these experiments.

The results of these experiments with chinook and blueback salmon indicate that a retardation in the time of initial feeding has a depressing effect on the growth rate of the fish. To obtain the maximum growth in small fingerlings, it is recommended that the fry be stocked in troughs just prior to the time when the first fish are free-swimming. Food should be presented as soon as the first fish swim up. Because fish at the latter part of the fry stage do not have a tendency to smother when placed in troughs, it is possible to stock the troughs with fry prior to the time when they are free-swimming or at the time when the first fish swim up. The application of this procedure in the production hatchery has resulted in a marked reduction in the number of emaciated, stunted fish and an acceleration in the growth rate of the stock.

SUMMARY

Under the conditions of these experiments, the following conclusions can be drawn:

1. The time when salmon are first capable of swimming up free of the bottom (which is an indication of the time when they will first take food) varies widely between individuals within a single day's egg take.

2. Retardation of the initial feeding causes a reduction in growth, decreases the efficiency of utilization of food, and increases the number of stunted and pinheaded fish.

3. Salmon which are fed when they first swim up suffer no greater mortality than those for which the initial feeding is delayed.

4. Chinook and blueback salmon should be fed when the first fish evidence a desire to feed if the maximum growth rate is to be attained. Salmon fry, therefore, should be stocked in troughs just prior to the time when the first fish are free-swimming.

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"P I G S" F O R K A M L O O P S

At the Summerland Hatchery of the British Columbia Game Department, rainbow trout fingerlings have recently received their diet of beef liver, salmon, and rice polishings in the form of blocks frozen about wire corkscrews.

A. Higgs, fishery officer at this hatchery, writes that the mixture is put into paper-lined half-cylinder containers of 60-pound capacity, metal slabs are inserted to form four 15-pound blocks, and into each block is thrust a wire corkscrew with a loop projecting above the mass of food. After being frozen, the "pigs" or blocks are dumped out of the container and are ready to be stored in the refrigerator or to be suspended from wire hooks attached to the screens over the fishponds. Mr. Higgs, reporting upon his experimental work with 167,200 fingerling kamloops divided equally among four cement raceways, points out that two blocks (30 pounds) per pond were consumed daily in about 2 hours.

Wonder whether Nature was anticipating the fly fisherman or the bait fisherman when she equipped the Reddish Frogfish with its long whiplike ray and enticing little lure? In any case, this fisherman with the "built-in" apparatus is probably less a sportsman than a meat-hunter--but strictly for home consumption.

MUSKELLUNGE YEARLING CULTURE AND ITS APPLICATION TO LAKE MANAGEMENT

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Woodruff, Wisconsin

THOUGH SOME reports in the literature indicate that certain warm-water game-fish species are not benefited by stocking, there seems to be a need for the introduction of fingerling and yearling muskellunge (Esox masquinongy) in waters infested with northern pike (Esox lucius) and panfish. Hile (1937:155) saw no relationship between the commercial fish takes on Lakes Huron and Michigan and stockings of walleye fry (Stizostedion vitreum vitreum), and Carlander (1942:16) could show no correlation between the stocking of walleye fry in Lake of the Woods and the commercial fish catch there. Although their conclusions indicate that the stocking of predator fish did not show an increased take of walleyes, it should be borne in mind that these studies were conducted on large bodies of water where pollution, erosion, and other factors can have a significant effect. There is only limited information on the success of stocking predator fishes such as walleyes, northern pike, and muskellunge, although Hiner (1943:14) stated that introductions of walleye fry may be classified as unsuccessful if they do not eventually form a portion of the fisherman's catch.

It should be pointed out that replacement of warm-water predators is often necessary following depletion by excessive hook-and-line fishing and such natural catastrophes as winterkill and depletion of summer oxygen. Little emphasis is placed on depletion of these predators by angling, mainly because conclusions on this phase of depletion can be drawn only from general conditions of once-famous walleye, northern pike, or muskellunge waters, as will be pointed out later in this paper.

The purpose of this paper is to elaborate on the production of larger muskellunge which can be utilized in conjunction with certain lake management practices.

WISCONSIN'S MUSKELLUNGE-PIKE PROBLEM

For many years the biologists and fish managers of the Fish Management Division of the Wisconsin Conservation Department reported that northern pike and muskellunge were incompatible in the same waters because of utilization of the same spawning area and similar feeding habits in the same habitat. In the northern Wisconsin waters where northern pike and muskellunge ranges overlap (Greene 1935:150-153), the northern pike begins its spawning activity under the ice, or immediately after the ice melts, late in March or early in April. Here the muskellunge generally begins its spawning activity during the last week in April or the first week in May, depositing its eggs in the same soft muck-bottom bays used by the northern pike. (See table 1.)

In 1941, the Fish Management Division undertook to discontinue stocking northern pike fry and fingerlings in four northeastern Wisconsin counties because cursory surveys indicated that certain promiscuous introductions of this species were made in native muskellunge waters to the detriment of the muskellunge population therein. The new policy calling for no northern

TABLE 1.--Spawning dates of northern pike and muskellunge in lakes of Oneida and Vilas Counties, Wisconsin

(Based on the Wisconsin Conservation Department's netting records and examination of fish during propagation operations)

Year	Spawning season	
	Northern pike	Muskellunge
1939	4/16 to 5/3	4/28 to 5/10
1940	No record	
1941	4/10 to 4/17	4/18 to 5/5
1942	4/14 to 4/24	4/22 to 5/2
1943	4/10 to 4/26	5/4 to 5/15
1944	4/14 to 4/24	4/28 to 5/13
1945	3/27 to 4/10	4/10 to 5/10
1946	3/29 to 4/16	4/14 to 5/4
1947	4/12 to 5/2	4/30 to 5/17
1948	4/9 to 5/2	4/22 to 5/5
1949	4/11 to 4/22	4/23 to 5/3

pike-stocking immediately brought criticism from some guides and sportsmen who were unwilling to accept the gravity of the situation. Further investigation by Department personnel disclosed that muskellunge populations were diminishing in waters where northern pike were introduced, and that hybridization (figure 1) was taking place in some waters. Natural hybrids have been reported from Boulder, Big St. Germaine, and Big Twin Lakes.

As reported by Elkins (1937:311), the waters of the Pike Lake Chain were once famous for muskellunge. Early in 1943, however, the Wisconsin Conservation Department was notified that northern pike--possibly the result of an unauthorized planting of fry in 1939--were beginning to appear in waters of Pike, Round, Rice, and Turner Lakes of the Pike Lake Chain. By 1945, an alarming situation was developing on the waters of this chain, as resort owners, guides, and interested sportsmen described unsuccessful fishing for muskellunge and a great upswing in the population of northern pike. After a review of the problem, it was decided that a large-scale removal program would be initiated in an attempt to eliminate as many northern pike as possible and to re-establish the muskellunge population by heavy restocking with yearling plantings.

Removal operations in the Pike Lake Chain were begun on a limited scale in April 1947 and were continued more intensively in the springs of 1948 and 1949. A total of 3,233 northern pike ranging from 10.5 to 35 inches were removed in the 3-year period. Netting in the 1949 season showed a slight decrease in the abundance and average length of northern pike present in the chain: the average length of 1,324 fish removed in 1949 was 16.6 inches, whereas 1,492 northern pike removed in 1948 averaged 18.8 inches. To complete this management program, removal operations will be continued in this chain water until a decided upward trend in the muskellunge population is observed. A total of 10,479 muskellunge fingerlings and 1,500 muskellunge yearlings have been stocked in the Pike Lake waters since 1947. The yearling muskellunge were stocked in the 1948-49 seasons, and as 5 years are required for the average Wisconsin muskellunge to reach a legal length of 30 inches, it is too early to determine the success of these plantings. The ultimate objective is to seed in a new muskellunge crop to offset the weight of the undesired northern pike.

It cannot be overemphasized that Wisconsin's native muskellunge population must be preserved at all costs. A yearling program as described here is a necessity if the pure strains of muskellunge are to be maintained. It is impossible to guess or to attempt to compute in any known manner the size of the muskellunge population now in Wisconsin waters. Many experienced guides claim that the muskellunge population is now in a better state than it was 20 years ago, whereas other guides claim that the muskellunge is just holding its own. Some authorities have even stated that the muskellunge is getting scarce (Hubbs and Lagler 1941:66). Whatever the size of the population, Conservation Department records indicate that the sale of resident and nonresident fishing licenses is increasing, and the sole objective of many nonresident fishermen in Wisconsin is to catch a muskellunge, thereby causing an increased drain on this portion of the fishery.

FIGURE 1.--Two-year-old hybrid of northern pike and muskellunge.

CULTURE OF THE MUSKELLUNGE YEARLING AS A MANAGEMENT TOOL

When consideration is given to the numerous problems encountered by the fish-culturist who attempts to rear predator fish to a larger size, it becomes apparent that these factors have not been touched upon by some investigators who have conducted studies to correlate stocking and subsequent production on natural waters. It has been demonstrated experimentally that only 4.6 percent survival from swimming fry stage to the advanced fingerling (6 to 8 inches) can be obtained from 6 acres of water used to produce muskellunge fingerlings with no regard to eliminating predators. When predation was reduced to a minimum, the survival up to 60 days was increased to 30.6 percent (Oehmcke 1949:6-8). This provides partial justification for stocking a larger fish for replacement after angling depletion.

Field and laboratory studies of the northern pike invasion of the muskellunge habitat had generally indicated that northern pike hatched and developed in the spawning habitat of the muskellunge eventually preyed upon the smaller muskellunge fry and took over the existing habitat. This particular point was debated by Department personnel with guides who were interested in obtaining continued hatchery plantings of northern pike in the counties having muskellunge waters.

To obtain some basis of fact for answering this question, an experiment was set up in a pond less than half an acre in area at the Woodruff State Fish Hatchery early in 1947. Northern pike eggs that were fertilized on April 30 hatched on May 15. Twenty-five thousand of these fry were stocked when they reached the swimming stage on May 25. Polyphemus, Daphnia, and other Cladocera were present in sufficient numbers to provide excellent starting feed for these fish. On June 5, 25,000 muskellunge fry resulting from eggs taken on May 3 and hatched on May 16, were stocked in the same pond with the northern pike.

Daily observations were made on the habits and occurrence of northern pike and muskellunge in this pond. Large numbers of both species were observed from June 5 to June 19.

After June 19, it was observed that large numbers of muskellunge were no longer present; between June 24 and July 10, when the pond was drained, muskellunge fingerlings could rarely be seen. Variations in size of the northern pike and muskellunge in the pond on the dates mentioned are pictured in figure 2. Although more than 35,000 shiners (Notropis) were removed from the pond on July 10, only 402 northern pike and 4 muskellunge remained (Oehmcke 1949). Apparently the northern

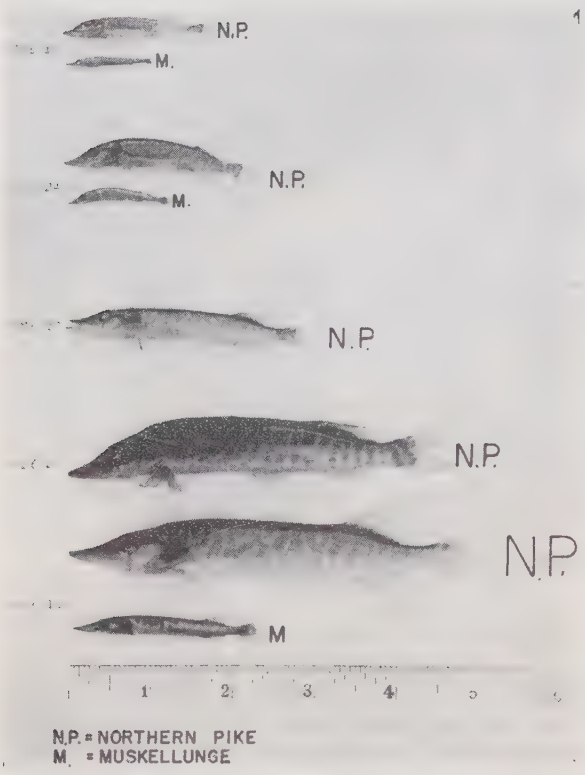

FIGURE 2.--Growth rate of northern pike and muskellunge fingerling in Woodruff Rearing Pond No. 8 in the spring of 1947.

pike preyed not only upon the smaller muskellunge fingerlings in the pond but also upon other northern pike in the pond, in spite of having sufficient forage at all times. It may be said that pond conditions will not simulate a natural lake, and an increase in cannibalism may be expected in a confined area such as this; on the other hand, it may be argued that the increased cannibalism brought about by this confinement is probably equalized by the fact that the predators normally evident in natural waters are eliminated from the experimental pond (Oehmcke 1949).

POND DESCRIPTION

The idea of rearing yearling muskellunge at the Woodruff State Fish Hatchery owes its origin in part to the problem of idle winter ponds. In former years, ponds were drained at the end of the muskellunge fingerling rearing season in September and they were left idle without refilling until the following spring. It was felt, however, that these ponds could be used to advantage during the winter months if sufficient circulation could be maintained to prevent the formation of excessive ice.

It will be noted that the major portion of the forage fish were stocked in the fall so that sufficient numbers would be available in the rearing ponds throughout the winter months when forage fishes were not obtainable and the ponds were covered with 8 inches of ice and 18 to 24 inches of snow. Forage fish were introduced into the ponds as late as November 1 in 1947 and November 15 in 1948 (table 2).

Approximately 80 to 90 gallons of water per minute (a much higher rate of flow than is necessary during the summer) was passed through each pond at all times. Intakes and outlets were screened to prevent the escape of muskellunge or introduction of other fish. Where complete circulation was provided with this amount of water, no mortality resulted from oxygen deficiency and the submerged aquatic vegetation thrived throughout the winter. Furthermore, hard gravel bottoms in the ponds minimized the possibility of oxidation.

During the 1947 and 1948 winter rearing seasons, 0.24 acre and 0.72 acre of pond area, respectively, were utilized successfully as rearing area for holdover muskellunge fingerlings. Each year, ice formed on the ponds in November and left in mid-March. Individual pond areas ranged from 0.08- to 0.40-acre areas. The ponds sloped gradually from a depth of 2 feet at the intakes to 5½ feet at the outlets. All ponds had hard gravel bottoms and luxuriant beds of waterweed (Anacharis canadensis), coontail (Ceratophyllum demersum), and some species of pondweeds (Potamogeton sp.).

About the only serious problem encountered with winter holdover ponds of this type in northern Wisconsin is the muskrat. Each fall at the Woodruff station young rats move from their normal habitat below the hatchery to the pond banks, which are ideal for tunnels and dens. Water loss through muskrat tunnels in the dikes must be watched very closely.

TABLE 2.--Fall and spring allocation of forage fish to muskellunge yearling rearing ponds at Woodruff

Season	Pond No. 1		Pond No. 2		Pond No. 3	
	Number of forage fish stocked	Date	Number of forage fish stocked	Date	Number of forage fish stocked	Date
Fall 1947	186,819	7/15 to 11/1	-	-	-	-
Spring 1948	36,000	4/13 to 5/28	-	-	-	-
Fall 1948	342,800	7/6 to 11/4	49,060	7/27 to 11/15	63,925	8/1 to 11/12
Spring 1949	None		None		None	

It was learned that this loss could be prevented most effectively by trapping the rats heavily early in the season.

REARING METHODS

Generally, in this operation, muskellunge fingerlings are reared until they reach an age of 12 months, thus making it an extended fingerling program. Actually, rearing muskellunge fingerlings to yearling size is a much simpler process than the technique involved in bringing the muskellunge fry up to a size of 5 or 6 inches.

Supplies of forage fish continue to be a major problem, but when sufficient forage is available in the fall and spring months, not much additional care is needed except for initial sorting of fingerlings and periodic removal of predators.

The manner of selection of muskellunge holdovers varied from 1947 to 1948. Near the end of the 1947 fingerling rearing season, muskellunge remaining in the rearing ponds at Woodruff after annual quotas had been satisfied were used for the yearling program. The fish were hand-counted and planted in Pond No. 1 on July 15 at a rate of 4,033 per acre. Sufficient numbers of forage fish had already been placed in the pond so that there would be no lag in the feeding routine of the young muskellunge. An average of 193 forage fish per muskellunge stocked in Pond No. 1 provided enough feed to attain a survival rate of 76 percent (table 3). The pond foreman observed that this percentage could have been increased if cannibalism had been eliminated by better sorting; on several occasions he reported large fingerlings consuming weaker inindividuals in the pond.

Although much time was consumed in sorting all muskellunge fingerlings in 1948, there was some difficulty in providing as much feed as in 1947. Thus, the attempt to increase the survival rate by sorting was somewhat negated by a lack of forage, which was undoubtedly the basic cause of increased cannibalism. In spite of this setback, 67.9 percent of the fingerlings reached the yearling stage (table 3). The stocking rate of 140 forage fish per muskellunge stocked, according to 1948-49 observations, is the bare minimum recommended but is hardly desirable for the production of large yearlings.

In 1948, three ponds received 3,071 muskellunge fingerlings at rates ranging from 3,000 to 8,200 per acre. No definite conclusions can be drawn as to the success of stocking rates on these ponds because other factors presented extremely variable conditions. It will be noted that all forage fish were stocked during the fall in the 1948-49 season (table 2). Most

TABLE 3.--Woodruff muskellunge yearling production, 1947-49

	1947-48	1948-49
Pond area (acre)	0.24	0.72
Number of muskellunge fingerlings stocked	968	3,071
Size (inches)	3.9 to 8	5.1 to 7.3
Rearing span	7/15 to 6/2	7/20 to 5/12
Total days reared	323	296
Forage fish stocked	186,819*	455,785**
Number of forage fish per muskellunge stocked	193	140.8
Muskellunge yearlings removed	736	2,085
Size (inches)	10 to 14.5	7.9 to 12
Weight	3 per pound	5.4 per pound
Percent survival	76	67.9

*Species breakdown

	(inches)	
Fatheads	1½	75,000
Shiners	1 - 1½	62,000
Yellow perch	2	15,000
Redbelly dace	1½ - 2	10,000
Black suckers	2	9,499
Creek chubs	3 - 4	7,820
Mud minnows	2 - 3	7,500
	Total	186,819

**Species breakdown

	(inches)	
Black suckers (hatched fry)		250,000
Shiners	1 - 3	155,600
Fatheads	2 - 3	23,500
Yellow perch	1½ - 2½	2,600
Golden shiners	2 - 3	685
	Total	455,785

TABLE 4.--Length/weight relationship of muskellunge reared to yearling size in Woodruff rearing ponds

Pond	Date	Number in sample	Length (inches) Minimum	Average	Maximum	Average weight (grams)
No. 1 (1947-48)						
	July 15, 1947	803	3.9	4.7	8.0	6.9
	August 1, 1947	85		6.5		18.1
	August 11, 1947	524		7.2		30.2
	August 30, 1947	60		10.5		79.0
	June 2, 1948	730	10.0	12.2	14.5	151.3
No. 2 (1948-49)						
	July 20, 1948	700	5.1	5.5	7.3	7.5
	August 11, 1948	660		6.5		28.3
	April 5, 1949	636		7.8		30.6
	*May 12, 1949	170	9.5	9.8	12.0	65.9
No. 4 (1948-49)						
	August 13, 1948	322	5.5	6.5	7.2	22.7
	August 20, 1948	879		7.3		32.7
	April 25, 1949	599	7.9	8.6	10.3	43.6

*Includes averages for all muskellunge in Pond No. 1 for 1949.

TABLE 5.--Costs of rearing muskellunge from the fry to the yearling stage at the Woodruff hatchery

	1947-48	1948-49
Fry		
Spring spawning costs for muskellunge fry	$4,140.24	$3,817.81
Muskellunge fry produced	(2,594,012)	(2,756,713)
Cost per 1,000 muskellunge fry	$ 1.5960	$ 1.3848
Fingerling		
Number of muskellunge fry transferred from hatcheries to muskellunge rearing ponds	(455,000)	(395,000)
Cost of above muskellunge fry	$ 726.18	$ 547.00
Number of propagated forage fish transferred to muskellunge rearing ponds for food	(37,796,851)	(41,497,876)
Cost of above forage fish	8,375.79	5,465.29
Cost of muskellunge rearing pond operations (includes forage minnow transfers)	7,197.96	11,803.17
Total cost	$16,299.93	$17,815.46
Total muskellunge fingerlings produced	(137,747)	(168,713)
Cost per muskellunge fingerling	$ 0.1183	$ 0.1056
Yearling		
Number of muskellunge fingerlings transferred to rearing ponds for holdovers	(968)	(3,071)
Cost of above muskellunge fingerlings	$ 114.51	$ 324.30
Cost of muskellunge yearling rearing operations	2,600.87	2,676.48
Total cost	$2,715.38	$3,000.78
Total muskellunge yearlings produced	(736)	(2,085)
Cost per muskellunge yearling	$ 3.6893	$ 1.4392

NOTE: Above costs do not include State administration; they are costs incurred at the Woodruff station only.

of the feed was consumed before spring, and no minnows were planted in the spring. The effects of this are reflected in the final survival percentage. The necessity to transfer all holdover muskellunge from Pond No. 2 to Pond No. 1 in April 1949 to accommodate a highway relocation project impaired the experimental value of both ponds. Data for Pond No. 2 on May 12, 1949, include average sizes for all muskellunge from Pond No. 1 and Pond No. 2 (table 4).

GROWTH

The young muskellunge consumed all species of minnows and perch without hesitation. If unlimited amounts of food were made available, it might be possible to produce better growth rates. The growth in the 1947-48 season was good, perhaps exceeding the average for muskellunge reported (Schloemer 1936:188) for various Wisconsin lakes. Growth in the 1948-49 season was definitely below the Wisconsin average (table 4). Feeding at the rate of 250 to 300 forage fish per muskellunge stocked would undoubtedly provide excellent, if not above normal, rates of growth.

COSTS

The long-term fishery program must fall

within the realm of economy and practicability before it can be considered by State administrators. The Wisconsin Fish Management Division keeps an accurate cost record of all functions of the propagation section. Data for the two yearling rearing seasons indicate that increased production lowers the costs (table 5). Because of the variables mentioned, the cost of $3.69 per muskellunge in the 1947-48 season cannot be compared with complete accuracy with the 1948-49 cost of $1.44. There is such a wide range in these costs that providing additional forage in the 1948-49 season would probably not have brought about any closer parallel. It will be noted, however, that increased production of fingerlings and the provision of additional forage fish resulted in a lower cost of fingerlings produced (table 5).

If future management findings prove the worth of large-size muskellunge introduction, the cost of $1.50 or $2 per fish will be considered a fair price to pay to redeem a lake over-ridden with panfish or other unwanted species.

ACKNOWLEDGMENTS

The writer is indebted to Messrs. G. E. Sprecher and Edward Schneberger for advice and suggestions in the preparation of this report; to Mr. Ernst Haslacher, Woodruff Hatchery Foreman, for assistance in recording data and management of experimental ponds; and to Mrs. R. L. Johnson for her able assistance with the manuscript. The table covering costs was prepared by Mr. Ralph Jones, Dispatcher, Wisconsin Conservation Department, Woodruff.

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THE TOXICITY OF PYRIDYLMERCURIC ACETATE TECHNICAL (PMA) TO RAINBOW TROUT *(SALMO GAIRDNERII)*

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PYRIDYLMERCURIC acetate (PMA) was introduced for the treatment of fish diseases by Van Horn and Katz in 1946. Since that time the popularity of PMA has increased rapidly, and now it is used very widely. Recent observations have indicated, however, that PMA is more toxic to rainbow trout (Salmo gairdnerii) than to any other of the salmonoid fishes. In support of this statement are presented the following observations made at the Cortland and Leetown (Kearneysville) Stations of the U. S. Fish and Wildlife Service.

At Cortland Station, in June 1949, there was one lot of yearling brown trout (about 9 inches in length) which were being held for future brood stock. As it was considered advisable to treat these fish with PMA before moving them to another pond, we began treatment, using a concentration of 1:200,000 in water at 13° C. (56° F.). In about 20 minutes, several fish were in distress and these were taken out and placed in untreated running water. In all, 30 fish were removed. All these were rainbows from an adjoining pool--rainbows which, some time before, had jumped across the raceway wall. Every rainbow in this lot was killed, but the browns went through the full hour of treatment with no loss.

The following day we treated brook trout fingerlings and noted similar results. In this lot, 101 rainbows which were present were killed, but not a single brook trout was lost. The temperature of this water, also, was 13° C. (56° F.).

In view of these two incidents, several experiments were designed to test the specific toxicity of PMA to rainbow trout.

In the Cortland hatchery we have two water supplies: the temperature of one is 8.5° C. (47° F.), and that of the other is 13° C. (56° F.). For one experiment, 200 fingerlings each of brook, brown, and rainbow trout were counted into six wire baskets, which made two baskets containing 100 trout of each species. Two adjoining troughs were set up, one with the colder water and the other with the warmer water. Enough PMA was added to give a concentration of 1:100,000 in each trough, and one basket of each species was placed in each trough. The baskets were shifted back and forth in the trough to avoid any possibility of "hot spots." Groups 1, 2, and 3 were run consecutively, a different lot of fish being used for each group. Results are presented in table 1. It appears that PMA is more toxic to rainbow trout and that its toxicity increases with rise in water temperature.

At the Leetown Station, during the last few years, pyridylmercuric acetate

TABLE 1.--The effect of temperature on the toxicity of PMA in 1-hour treatments of three species of trout

Trout	Temperature	Concentration of PMA	Loss
	Group 1		
Brook	47° F.*	1:100,000	0
Brown	47° F.	1:100,000	0
Rainbow	47° F.	1:100,000	33
Brook	56° F.**	1:100,000	0
Brown	56° F.	1:100,000	0
Rainbow	56° F.	1:100,000	99
	Group 2		
Brook	47° F.	1:200,000	0
Brown	47° F.	1:200,000	0
Rainbow	47° F.	1:200,000	3
Brook	56° F.	1:200,000	0
Brown	56° F.	1:200,000	0
Rainbow	56° F.	1:200,000	36
	Group 3		
Brook	47° F.	1:400,000	0
Brown	47° F.	1:400,000	0
Rainbow	47° F.	1:400,000	0
Brook	56° F.	1:400,000	0
Brown	56° F.	1:400,000	0
Rainbow	56° F.	1:400,000	2

* 47° F. equals 8.5° C.
** 56° F. equals 13° C.

has been used with good results in the treatment of gill diseases. Often, however, when rainbow trout have been treated in the circular pools, some trout--usually the largest fish in the lot--have died within 24 hours after treatment. So far, the significant losses have never occurred among small fingerling rainbow trout held in the hatchery troughs. The temperature of the water at the Leetown Station is very stable the year round, ranging from 11° to 13° C. (52° to 56° F.).

On January 24, 1950, the fish in two circular pools at Leetown Station were treated with PMA at a concentration of 1:400,000 for 45 minutes. One of these pools contained brook trout and the other a mixture of brook and rainbow. Within 24 hours, the pool with the mixed population showed a loss of 13 rainbow, while there were no losses in the pool that contained only brook trout.

On March 22, 1950, at Leetown Station, PMA at a concentration of 1:400,000 was applied for 30 minutes to a circular pool that contained 300 brown trout adults, 5 brook trout adults, and 19 rainbow trout adults. Three hours after treatment, 3 rainbow trout died; in addition, 14 rainbow trout died during the night. Only the two smallest rainbow trout survived. None of the other species died.

It has been noticed that rainbow trout treated with PMA do not eat well after treatment. In order to test this observation, rainbow trout fingerlings, 60 millimeters or 2 to 5 inches average size, in the hatchery troughs at the Leetown Station were divided on March 30, 1950, into three groups of 10 troughs each. Trout in one group were treated with PMA at a concentration of 1:400,000; trout in the second group were treated with roccal (commercial 10 percent solution) at the rate of 1:40,000; and the third group was used as a control. Distribution of treatments was fully randomized. Treatment lasted for 30 minutes, and the flow of water in the controls was stopped for the same length of time. The temperature of the water was 12° C. (54° F.). Thirty minutes after treatment, all trout were fed the usual diet (percentage composition: beef spleen, 50; fish meal, 24; wheat middlings, 12; cottonseed meal, 12; and salt, 2). The behavior of trout was recorded by persons who did not know the distribution of treatments. Trout were restless in all troughs treated with PMA and in three troughs treated with roccal. Two hours (12:00 noon) after the completion of the treatment, much food was still left in all troughs of fish treated with PMA and in three troughs containing fish treated with roccal. At this time the remaining food was flushed out. Five hours after treatment, and next morning, the trout were fed again; and the degree of food consumption by the fish was recorded half an hour after each feeding. See table 2. In none of the troughs, within 24 hours after treatment, were

there any mortalities which could be attributed to the effect of disinfectants. This experiment indicated that treatment with PMA reduced the appetite of rainbow trout for almost a day. When compared with the control trout, roccal-treated trout showed only an insignificant effect.

Another test was made at the Leetown Station on June 24, 1949, to test the effect of feeding on the treatment with PMA. Normal, healthy rainbow trout fingerlings about 75 millimeters (3 inches) long were distributed among experimental troughs. After several days of adjustment to the new conditions, trout in half of the troughs were fed 10 minutes before treatment with PMA in concentrations of 1:200,000 and 1:400,000 for 1 hour at 12° C. (54° F.). All trout survived the treatment, and there were no losses among treated and control trout during the following 2 days of observation.

The mortalities among rainbow trout treated with PMA do not occur regularly. It seems obvious, therefore, that certain conditions in the fish or in the water affect the susceptibility of rainbow trout to PMA. Results here reported indicate that the losses increase with the rise in the temperature of water.

Regardless of the toxic effect of PMA on rainbow trout (See experience noted by W. R. Seaman, PROGRESSIVE FISH-CULTURIST 12 (3): 126), this disinfectant still must be considered as very valuable in the control of gill diseases and external infestations by some parasites. Further observations may reveal a method of reducing the toxicity of PMA to rainbow trout without decreasing its therapeutic properties.

TABLE 2.--The effect of treatment on the appetite of rainbow trout fingerlings

Treatment given to 10-trough groups*	Number of troughs in which some food was left hours after treatment	
	5	20
PMA	10	9
Roccal	5	3
None (controls)	4	1

* Water temperature, 12° C. (54° F.)

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A MOUTHLESS BUFFALOFISH FROM MISSISSIPPI

This bigmouth buffalofish, Megastomatobus cyprinella (Valenciennes), was captured by a "round-up" seine in Moon Lake, Mississippi, on November 6, 1950. Such capture, however, probably represented only the culmination of this fish's misfortunes, as it apparently had had no mouth since birth.

Jefferson C. Fuller, Jr., fisheries biologist of the Mississippi Game and Fish Commission, reports from his station at Friar Point that at the time of capture the fish was 3 years old, measured 21.1 inches in total length, weighed 4 pounds 4 ounces--and had absolutely no mouth. Although it appeared slightly poor when compared with other buffalofish of similar length and age, this specimen seemed to be in fair shape; it was very active. Fuller points out that small strands of lodged algae were observed in the gills, indicating that food intake was entirely by this method. The apparent lack of any scar tissue indicated that this unusual condition had existed since birth.

The fish was forwarded to Miss F. A. Cook of the Mississippi Game and Fish Commission Museum and Laboratory for examination. Miss Cook states that the fish was absolutely without a mouth, and that her examination of the internal anatomy revealed no irregularities.

Preliminary observations in the Carp Lake River (Michigan) have indicated that the young sea lamprey may be considerably more difficult to electrocute at given voltage levels than any species of fish native to this area.

SOME EXPERIMENTS ON THE USE OF THIOURACIL AS AN AID IN HOLDING AND TRANSPORTING FISH

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ONE OF THE present problems in the propagation and stocking of game fish and in the distribution of bait fishes is the loss that occurs when fishes are transported for long distances. If the rate of metabolism of the fishes could be lowered, or if the resistance to low oxygen content could be increased, more fish per trip could be safely transported. Keeping the water cold by frequent icing is one method of lowering the oxygen consumption of fish, but this method is inconvenient and necessitates the acclimation of the fish.

At the suggestion of Dr. Kenneth D. Carlander and Dr. R. M. Melampy of Iowa State College, it was decided to try thiouracil, a new drug. A search of the literature revealed very little information regarding the effects of thiouracil on fresh-water game, food, or bait fishes.

Thiouracil is the name used for 2-thio-6-oxypyrimidine, a sulphur-bearing compound. From the many compounds which retard metabolic rate, thiouracil was selected for trial because of its availability and low cost. One of the most important effects of thiouracil on an organism is a reduction in the amount of hormone produced by the thyroid gland. This reduced production of thyroid hormone results in a reduction of the rate of metabolism of the organism and consequently in a reduction of the oxygen consumption and carbon-dioxide output. However, as Thyssen (1947) has stated that methylthiouracil and phenylthiouracil have stronger strumigenic effects than thiouracil, these compounds should be tried in further investigation along these lines.

Materials and Techniques

Thiouracil was used in both the tablet and the powdered form. The powdered form was more readily dissolved, whereas the tablets were more easily handled. No difference was noted in the effects of the two forms. Thiouracil was dissolved in warm water before being placed in the aquaria containing the fish. The durability of thiouracil in aqueous solution for at least 4 weeks has been demonstrated (Thyssen 1947). Administering thiouracil by means of a continuous bath was chosen for a number of reasons, among these being the ease of administration by this method and its application to future use.

Dosage and Mortality

An attempt was made to find the maximum dosage which could be used without excessive mortality. Goldsmith and Harnly (1946) found no evidence of toxicity following immersion of young aquarium fish (Xiphophorous hellerii and Platypoecilus

From the Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College.

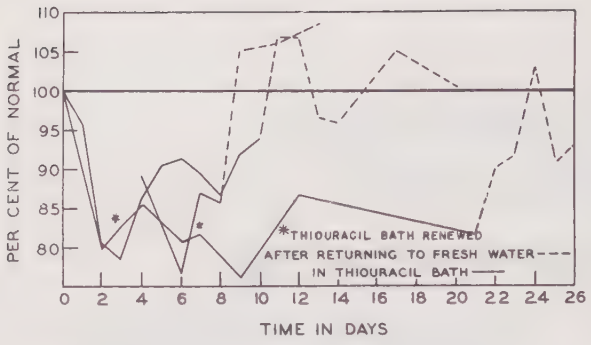

FIGURE 1.--Metabolic rate in percentage of normal of stonerollers in thiouracil bath with controls plotted as the normal (100 percent).

maculatas) in water containing 33.3 milligrams of thiouracil per 100 cubic centimeters (333 parts per million) for periods as long as 5 months.

On January 21, 12 grains of thiouracil were added to 15,000 cubic centimeters of tap water (517 parts per million) in which 26 stonerollers (Campostoma anomalum pullum) weighing 139 grams were living. After 21.5 hours, three fish were dead and several others were acting in a peculiar manner, gyrating in the water. Another fish died a few minutes later, and the fifth died on the following day. Altogether, 12 of the 26 fish died before the end of the experiment on February 7. In a control aquarium, 2 of 16 stonerollers died in the same period. When the dosage was reduced to 9 grains of thiouracil in 15,000 cubic centimeters of water (388 parts per million), the mortality did not exceed that of the controls. Stonerollers and bigmouth shiners (Notropis dorsalis dorsalis) were used at this concentration, and results for these species were similar.

Effect of Thiouracil on Oxygen Consumption

To test the oxygen consumption, minnows were sealed in jars for 90 minutes and the dissolved oxygen in parts per million was determined at the beginning and the end of the experiment. Preliminary experiments showed no reduction in oxygen consumption of the minnows until several hours after they had been placed in the thiouracil solutions, nor any increase in oxygen consumption immediately after removal to fresh water.

The effects of thiouracil on the rate of oxygen consumption in stonerollers are shown graphically in figure 1. In each of the three series, the oxygen consumption of the controls is considered as normal and the oxygen consumption of the fish in thiouracil baths is plotted as percentage of normal.

The stonerollers in the series shown in figure 1 as starting on the fourth day--the first oxygen determinations were made on this day--were in a bath of 12 grains of thiouracil per 15,000 cubic centimeters of water, while the two other series were in baths of 9 grains of thiouracil per 15,000 cubic centimeters of water. In one of these two series, the thiouracil bath was renewed on the third and seventh days, as shown by the asterisks.

The decrease in oxygen consumption was slight the first day after the fish were placed in the thiouracil solutions, but by the second day oxygen consumption was 20 percent below that of the controls. The metabolic rate then gradually increased unless the thiouracil bath was renewed. Renewal of the bath again lowered the metabolic rate.

There was a pronounced increase in oxygen consumption soon after the fish were placed in plain tap water, but this increase was slower in the fish kept in thiouracil for 22 days than in those kept for 9 to 11 days. The oxygen consumption went above normal for awhile and then dropped below normal again in two of the cases. Thyssen (1947) reported a similar pattern for rats treated with thiouracil.

Ability to Stand Low Oxygen Concentrations

It was believed that thiouracil-treated fish might be able to live in water of lower dissolved oxygen content than untreated fish required. The dissolved oxygen content of the water at 61° to 63° F. at the time of death of 13 individual stonerollers not given thiouracil, ranged from 1.9 parts per million to 0.2 part per million and averaged 0.5 part per

million. In an experiment at 62° F., all of seven control stonerollers in each of two jars were dead when dissolved oxygen concentration reached 0.2 and 0.3 part per million, whereas no dissolved oxygen could be detected at time of death of the seventh stoneroller in the jar containing seven stonerollers which had been in a bath of thiouracil for 4 days.

In a similar experiment, the oxygen determination was made at the time of death of the fourth fish of seven. Two jars contained stonerollers which had been in a thiouracil bath for 21 days but which had been out of the thiouracil for the 6 days immediately preceding the experiment. The dissolved oxygen of the water at time of death of the fourth fish in these two jars was 0.4 and 0.45 part per million, whereas the dissolved oxygen content in the jar of control fish at time of death of the fourth of seven fish was 0.65 part per million.

Growth of Stonerollers in Thiouracil as Compared to Growth in Controls

As stated in the introduction, the main purpose of this investigation was to determine the effect of thiouracil on the metabolic rate of minnows. There appeared, however, a very interesting differential in the weights maintained by the controls and by the fish in thiouracil baths.

The weights of fish in thiouracil and the weights of the control fish remained together for the first several days but then diverged widely. In one experiment the weight of stonerollers in thiouracil was 27.9 grams on the sixth day and 27.9 grams on the twenty-third day, whereas the weight of the control group was 27.5 grams on the sixth day but had dropped to 23.5 grams on the twenty-third day (figure 2). In another, the weights of the two groups of controls and the two groups of stonerollers in thiouracil averaged 24.05 grams at the start of the experiment, whereas on the eleventh day the two groups in thiouracil averaged 24.65 grams and the two control groups averaged 22 grams.

The fish in thiouracil not only lost less weight (actually gained weight in the second series) but also had increased appetites, a condition which was very evident in the speed with which these fish cleaned up the food in their aquaria. Published findings show little agreement regarding the effect of thyroid extract or thyroid depressants on the growth and weights of various animals, or even on the same animal.

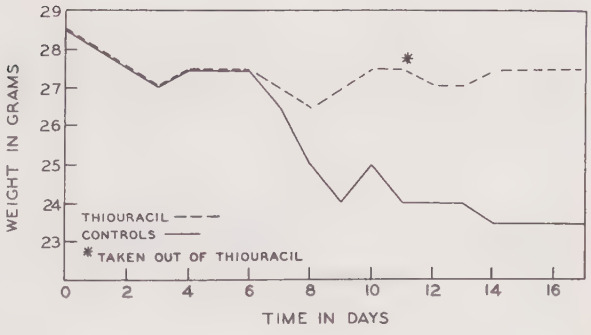

FIGURE 2.--Weight of stonerollers in thiouracil as compared with weight of controls. Series A, thiouracil not renewed.

Discussion

The principal purpose of this study was to investigate the possibilities of the use of thiouracil in the transportation and holding of fish. It was thought that if thiouracil reduced the metabolic rate of fishes as the drug does other animals, larger numbers of fish might be held for longer periods of time in shipping tanks or minnow buckets.

The oxygen consumption was reduced about 20 percent with dosages of thiouracil, which appeared to cause no mortality. In addition, the ability of the minnows to stand lower concentration of dissolved oxygen seemed to be increased by the thiouracil treatment. It would appear that after thiouracil treatment it might be possible to hold 15 to 20 percent more fish in the same quantity of water and for the same length of time that it is possible to hold untreated fish. Further experiments are needed, but the results so far indicate that further research would be profitable. It is possible that other metabolic-inhibiting chemicals would give us even better results.

Observations on the effect of thiouracil on growth, food consumption, and survival suggest that the chemical might have some uses in the rearing of fish.

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In an attempt to eliminate the expense, labor, and time required for draining ponds, traps of the type shown in one of the bluegill rearing ponds of the U. S. Fish-Cultural Station at Marion, Alabama, have been used to collect fish for day-to-day distribution trips.

AN EVALUATION OF METHODS OF EGG ENUMERATION

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MOST FISH-CULTURAL organizations require certain definite records and reports concerning fish-cultural operations. The accuracy of the records on which the reports are based is dependent on the methods used to determine the number of eggs taken or received and the number of fish planted or transferred. As pointed out by Hewitt and Burrows (1948), the accuracy of fish enumeration is dependent on the sampling method and is complicated by the fact that a motile organism is involved. The accuracy of egg enumeration, on the other hand, is dependent only upon the accuracy and applicability of the method of enumeration employed--and is not complicated by the presence of a motile organism. The egg stage, therefore, offers the best opportunity for accurate enumeration.

Since the beginnings of salmon and trout culture, men have tried to estimate the number of eggs taken into the hatchery. That these early efforts were crude and grossly inaccurate is to be expected. Page (1888) attempted a refinement of earlier methods by using the average number of eggs per quart for each species instead of the estimate of the number of eggs contained in one or more females presumably representative of the entire run. This method was probably an improvement over earlier procedures, but it must have been a crude estimate at best because of the variations in egg size within a species. Von Bayer (1908) devised a sampling technique which employed the principle that the volume of a sphere varied as the cube of its diameter. With this technique, by the determination of the average egg diameter of sample groups, it was possible to estimate the number of eggs contained in large volumetric measurements.

Between 1908 and 1933, several egg enumeration techniques were evolved. Schaeperclaus (1933) recommended four methods of measurement: a weight technique using 1,000 egg samples, a volumetric method using 1,000 egg samples to determine the volume per egg, a displacement method in which the amount of water displaced per egg was determined by the Von Bayer sampling technique, and another volumetric technique in which the number of eggs per unit of measure was determined by means of a counting board.

A survey of fisheries techniques in the United States and Canada (Rodd and Stapledon 1941) indicated that all the reporting agencies were using the volumetric method of measurement but differed in their methods of sampling. Seven organizations computed the number of eggs on the basis of an actual count of unit measures, one used the Von Bayer sampling technique, and another estimated the number of eggs from small sample counts. The results of this survey indicated that, in America at least, little or no alteration in egg enumeration techniques had

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See also:

James, M. C.
1935. Hatchery records and accounting. Prog. Fish-Cult. 2: 1-4

been made since the early 1900's.

In the design of the present experiment, the original problem was defined as an evaluation of the accuracy of egg enumeration methods being used in North America. The preliminary work, however, indicated that such gross errors occurred in the established methods as to preclude their use other than for very gross estimates. To circumvent this difficulty, there was developed at the Leavenworth Laboratory a displacement method of measurement which eliminated the obvious sources of error in the standard methods of enumeration. Later, a weight method of enumeration was developed by B. B. Canady of the U. S. Fish-Cultural Station at Anderson, California (unpublished manuscript). This weight method, when tested at the Leavenworth Laboratory, was improved by the elimination of some of the obvious variables.

PRELIMINARY EXPERIMENTATION

The methods of egg enumeration commonly employed in North America involve two operations: the measurement of the total amount, and the sampling of the lot to determine the average size of the individual units. All the techniques in common usage employ the volumetric method of measurement, wherein the actual volume of eggs submerged in water is used to determine the total amount. In general use in the United States, however, are three sampling methods: the Von Bayer technique, total counts of small samples, and counts of unit measures.

In this preliminary work, certain sources of error were obvious in both the method of measurement and the sampling techniques. In the volumetric method of measurement, the determination of the actual volume of eggs, submerged in water, is attempted. At least two factors complicate the method. Salmonoid eggs, although demersal, are semibuoyant and are not readily compacted. It is necessary to agitate the container in order to reduce the interstices to a minimum, and the degree of agitation varies between different operators and from one measurement to another by the same operator. The second factor affecting total measurement is the difficulty encountered in determining the center line of the top layer of eggs, particularly when large eggs are being enumerated.

To evaluate the Von Bayer and small-sample techniques, the number of eggs per quart was determined by each of these procedures and then compared with actual counts of the eggs. Statistical analysis of the results indicated that significant differences existed between the actual and calculated numbers of eggs when either method of sampling was employed.

The Von Bayer sampling technique is based on the geometric principle that the volume of a sphere varies as the cube of its diameter. To apply this principle to salmonoid egg measurement is to ignore the fact that as the eggs develop and become less turgid, they cease to retain a constant diameter but vary in shape with the pressure exerted on them. Any method which relies on the unstable egg diameter will be subject to gross inaccuracies.

In the preliminary evaluations and all subsequent comparisons, salmon eggs preserved in formalin were used. Such eggs are hard and relatively incompressible. Even with this type of egg, the Von Bayer sampling method produced a biased statistic.

Evaluations of the small-sample method consisted of actual counts of 4-ounce samples. All the difficulties encountered in the gross measurements were present in this method, and the probability of error was enhanced by the small samples.

The counts of unit measures to determine the total number of eggs should not show the errors encountered in the other sampling methods, provided that an adequate number of samples is counted. Because the counting of large numbers of eggs is a slow, tedious process at best, the tendency is to count but a few unit measures. Because all egg sizes are not uniformly distributed throughout a season nor within an individual day's take, a few large samples may not adequately represent the entire population. Numerous counts of unit measures, although extremely accurate, are obviously impracticable.

The gross errors encountered in these

preliminary evaluations indicated that any of the accepted egg-measuring methods provided but a crude estimate of the actual number of eggs. Three methods of egg enumeration were developed in an effort to produce a procedure more accurate than those in general use.

DESCRIPTION OF THE METHODS EVALUATED

Four methods of egg enumeration were selected for evaluation: the Von Bayer sampling technique combined with volumetric measurement, the Leavenworth displacement method, the Canady weight method, and the improved weight method. As the last three are newly developed procedures and there is some variability in the application of the Von Bayer technique, a brief description of each method will be given.

The Von Bayer Method

In sampling by the Von Bayer method, the eggs were placed in a 12-inch, V-shaped trough until a single row of eggs completely or nearly filled the length. All eggs in excess of this number were removed. If the eggs were of such size that the trough could not be completely filled without crowding, estimates of the space remaining were made to the nearest one-half egg. Once the average diameter of the eggs in the trough had been ascertained, the number of eggs per quart was determined by reference to the Von Bayer table as extended by Donaldson for larger egg sizes.

Total measurements were made in a 32-ounce graduate which was calibrated at 2-ounce intervals. The submerged eggs were thoroughly agitated to reduce the interspaces to a minimum before eggs were added or subtracted to bring the center line of the top layer of eggs to the 32-ounce mark. The final measurement in each lot of eggs was made to the closest half an ounce by approximation.

The Displacement Method

The displacement method has been described in detail by Burrows (1951). The water displaced by the 50-egg samples was measured to the nearest 1/10 milliliter in a 50-milliliter burette, accurate to 1/10 milliliter, in which a 25-milliliter base water level was used.

The total measurements were made in a container of 160-ounce capacity with a gauge calibrated at every 1.1 ounces. Approximations were made to the nearest half graduation. Before measurement, the eggs were drained for a period of not less than 1 minute.

The Canady Weight Method

A weight method of measurement was developed by Canady while engaged on the Shasta Salmon Salvage Project. Because a description of the method has not been published, a detailed description of this procedure will be given.

To determine the average weight of the eggs in a lot, samples of 100 eggs each are selected by means of a sampler. This sampler consists of 10 strap-iron strips, each 4 inches long by 1/2 inch wide by 1/8 inch thick, set parallel to each other at 1/2-inch intervals and welded at each end to a rod of 1/8-inch diameter. Each strip contains 10 egg wells which taper from a 3/8-inch diameter at the top to a 5/32-inch diameter at the bottom. Between the fifth and sixth strips, on one side, a short strap-iron handle is attached. The completed sampler is 4-1/4 inches wide by 9-1/2 inches long and has a capacity of 100 eggs.

In operation, the sampler is immersed gently into the eggs to be sampled and drawn upward through them. The eggs trapped in the wells are retained and the excess eggs roll off. The 100 eggs secured by the sampler are drained by tilting the sampler at a 45° angle from the horizontal for 10 seconds and then reversing the angle for an additional 5 seconds. The sampler and eggs are weighed on a triple-beam balance sensitive to 1/10 gram.

The tare of the sampler is ascertained by deduction. The weights of 100 samples including the sampler are determined. These samples are put into a basket of known weight and the total weight of the lot is then determined. The difference

between the total weight of the basket and eggs after draining and the initial weight of the basket is the weight of the eggs; and the difference between the total weight of the samples and the weight of the eggs, divided by the 100, is the average tare of the sampler. According to Canady, the determination of the tare of the sampler must be repeated for different egg sizes.

The total weight of the eggs in a lot is determined by the introduction of the eggs into baskets whose dry weight is known. The eggs, then, are drained for a 20-minute interval by removing the baskets from the water and placing them at an angle between the troughs. After draining, the weights of the drained baskets and eggs are taken on a solution balance sensitive to 1 gram. The difference between the weight of the dry baskets and the total weight of the baskets and drained eggs is the weight of the eggs.

Division of the net weight of the eggs by the average weight of the individual eggs determines the number of eggs in a lot.

The Improved Weight Method

The preliminary tests with the Canady weight method of measurement indicated that though the estimates were unbiased, the range of variation within the method was so great as to preclude its use except where large lots of eggs were to be enumerated. The principle involved, however, seemed sound and worthy of development.

Two sources of error were apparent in the Canady method. In the Canady method the baskets of eggs are drained by being tilted at an angle and allowed to stand for 20 minutes or longer. This method of draining allowed a variable amount of water to remain in the basket. Repeated weights taken on the same basket of eggs indicated a range of variation of more than 2 percent in the net weight. An even greater variation was observed in weights taken on the sampler. Apparently surface tension in both the basket and the sampler prevented a consistent removal of residual water.

In the improved weight method, blotting pads are used to drain the baskets and the sampler. The pad used to drain the baskets consists of many layers of cheese cloth or turkish toweling folded to a size slightly larger than the bottom of the basket. The thickness of the pad ranges from 1/2 inch at the side to 3/4 inch at the center. The pad is supported by heavy gauge wire cloth of 1/4-inch mesh mounted on a slatted, wooden framework. In the draining procedure, the pad is soaked with water and then the basket containing the eggs is placed on the pad. The operator places a hand at each end of the basket and applies pressure to both ends of the basket simultaneously, allowing his weight to rest on his hands. Pressure sufficient to insure that the entire bottom of the basket comes in firm contact with the pad is alternately applied and released at 2-second intervals, 10 times. The draining operation requires 40 seconds, after which the basket of eggs is weighed and returned to the trough. The alternate application and release of pressure creates a barely perceptible disturbance in the eggs--sufficient to break the surface tension of the residual water--and, at the same time, increases the absorbent action of the blotting pad. The difference between the dry weight of the basket and the gross weight of basket and eggs is the weight of the eggs.

A small blotting pad and frame comparable to the one used for the baskets is employed for the sampler. After the egg wells have been filled, the sampler is removed from the water, placed on the saturated pad, and tilted at a 30° angle with the horizontal so that one of the long edges is in direct contact with the pad. The operator applies sufficient pressure to raise the eggs slightly in the wells which are in direct contact with the pad, and then, maintaining this pressure, rotates the sampler in the vertical plane so that all the egg wells come in direct contact with the pad. As the last row of eggs is reached, the sampler is tilted to a 30° angle and the rotation is repeated in the opposite direction. Counting each rotation from front to back or back to front as one, the operator repeats the movement 10 times. After the draining process is completed,

the sampler and eggs are weighed. The difference between the dry weight of the sampler and the gross weight of the sampler and eggs is the weight of the 100-egg sample. In this procedure the process used to determine the tare of the sampler in the Canady weight method is eliminated.

Use of blotting pads has proved very effective for the consistent removal of residual water. Repeated weights of the same basket of eggs indicated a range of variation of less than 1 percent in the net weight by this method.

The scales and equipment, other than the variations mentioned, are identical to those used in the Canady weight method, and the calculations necessary for the determination of the total number of eggs in a lot are similar.

EXPERIMENTAL RESULTS

Two criteria, the accuracy of the method and the time required for measurement, were used to evaluate the four methods of measurement selected for test. Though accurate estimates are essential, the method must not be so cumbersome and slow as to be impracticable for production operations.

In these evaluations, the Von Bayer method of sampling combined with the volumetric method of measurement was used as the basis for comparison with the three more recently developed methods. In general use by the Fish and Wildlife Service and accepted as a practical hatchery procedure, the Von Bayer method is one of the speediest used on this continent. Preliminary trials indicated, also, that it is as accurate as the 4-ounce-count method of sampling.

The accuracy of the methods was determined by comparing estimates of the number of eggs in a lot with the number actually present in the lot. Formalin-preserved eggs of blueback (Oncorhynchus nerka), chinook (O. tschawytscha), and silver salmon (O. kisutch) were used in the tests. One lot consisted of 25,889 blueback eggs, another lot consisted of 16,470 blueback eggs, a third consisted of 10,178 silver salmon eggs, and the fourth was composed of 8,681 chinook salmon eggs. These groups covered the range in egg sizes to be expected in salmon culture and, except for extremely small sizes, in most trout work.

For statistical analysis, 30 samples and 15 total measurements were made on each lot by the Von Bayer method, the displacement method, the Canady weight method, and the improved weight method. Fifteen sets of 5 samples each, selected by random numbers, were combined with the total measurements to form 15 enumerations on each lot by each method. The significance of differences between the actual and calculated counts was determined, and the degree of variability to be expected in each method was ascertained.

Of the four methods, only the Von Bayer technique produced a biased statistic in that a highly significant difference was found between the actual and calculated counts.

The variation to be expected in each method, when the mean of five samples and one total measurement are used to arrive at the estimate, is shown in table 1. This measure of the variability is quite rigorous in that the mean of five samples and one total measurement form the smallest enumeration which would normally be made. In all the unbiased methods--which excludes the Von Bayer technique--a greater number of samples and more total measurements would cause the variability in the estimates to decrease and more closely approach the actual number. On large lots of a million or more eggs, the error in the estimate by any of the unbiased methods should be insignificant.

Of the methods tested, the displacement technique was the most accurate. As indicated in the preliminary tests, the Canady weight method showed a wide variability. Obviously, the changes made in the draining of the eggs and incorporated in the improved weight method reduced this variability. Though the Von Bayer method showed less variability than the Canady weight method, the bias of the Von Bayer method made it an undesirable technique. If the character of the eggs remained constant throughout their development, it might be possible to introduce a correction factor into the calculation,

TABLE 1.--The fiducial limits of four methods of egg enumeration determined from 60 estimates by each method

(Each estimate is based on the mean of 5 samples and 1 total measurement.)

Method	Range of method at 5 percent level	Range of method at 1 percent level
Von Bayer	1.61% to 10.17%	-1.97% to 13.75%
Canady weight	-5.40% to 5.50%	-9.92% to 9.92%
Improved weight	-3.39% to 3.39%	-6.24% to 6.24%
Displacement	-2.77% to 2.77%	-5.08% to 5.08%

but the fact that the eggs become progressively more flaccid makes such a procedure impracticable.

The accuracy of a procedure means little if the technique is not applicable to actual hatchery procedure. To determine the time necessary for enumeration, exact records were kept of the time required to make the 60 measurements and 120 samples by each method. By prorating the time required for the total measurement of 1,000,000 chinook eggs and the selection of 60 samples, it was possible to arrive at a comparison of the time required for enumeration by each method. Admittedly, this evaluation is an extremely severe test in that chinook eggs are the largest species normally measured and the time required for measurement is therefore the greatest to be expected. Egg takes of this size are not normally encountered in trout culture; hence, to be practicable, the evaluation should be made with a species in which large daily takes do occur.

The estimated time required to enumerate 1,000,000 chinook eggs by each of four methods is given in table 2.

The Von Bayer technique required the greatest number of man hours for enumeration. As this method is considered practicable and the other methods required fewer man hours, the three new procedures may be considered applicable to hatchery operations.

The rapidity with which enumerations may be made by either weight method is of extreme significance to the operating personnel of a large fish-cultural station. The difference in time between the two methods is so small as to be of little importance, but in view of the greater accuracy of the improved weight method, this technique is definitely the superior.

The displacement method, although practicable, required twice the time required by either of the weight methods. It is doubtful that with large lots of eggs the difference in accuracy between the improved weight and displacement methods would be significant. On small lots of eggs, up to 500,000, where the time required for measurement assumes less significance and maximum accuracy in the estimates is desired, the displacement method would be superior to any of the others tested.

TABLE 2.--Estimated time required to enumerate 1,000,000 chinook salmon eggs by each of four methods

Method	Man hours required for measurement	Man hours required for 60 samples	Total man hours
Von Bayer	6.50	2.00	8.50
Displacement	4.00	3.00	7.00
Improved weight	2.00	1.75	3.75
Canady weight	2.00	1.50	3.50

From these evaluations it may be concluded that the displacement and improved weight methods are superior to the Von Bayer and Canady methods if both accuracy and time required for measurement are considered. Whether the displacement or the improved weight method should be employed would depend upon the number of eggs to be measured, the time available for measurement, and the accuracy desired.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of these evaluations, the following conclusions and recommendations are listed:

1. The volumetric method of egg measurement has certain inherent characteristics which make accurate measurement extremely difficult. Also, the method is unjustifiably time-consuming. This method should be abandoned.

2. The Von Bayer method of sampling does not produce a reliable statistic and therefore cannot be recommended.

3. Small sample counts which employ the volumetric method of measurement are subject to all the inaccuracies of the larger measurements further aggravated by small samples. Moreover, this sampling technique is particularly time-consuming if the lot is to be sampled adequately. There appears to be no justification for the employment of this sampling technique if either speed or accuracy is desired.

4. The counts of unit measures should give an accurate estimate of eggs measured by the volumetric method if a sufficient number of samples is taken. As the time required to count a sufficient number of unit measures would be excessive, this method of sampling is obviously impracticable.

5. The Canady weight method shows too much variability to be practicable except where large lots of eggs are being enumerated.

6. The improved weight method is particularly applicable for the enumeration of large lots of eggs. Its accuracy, reliability, and speed recommend its use at fish-cultural stations where the daily takes are in excess of 500,000 eggs.

7. The displacement method of egg enumeration is the most accurate of the methods developed to date. It is, however, time-consuming and therefore inferior to the improved weight method for the enumeration of large egg takes. Where maximum accuracy is desired, as in scientific work, and where the time element does not assume paramount importance, as in daily takes under 500,000 eggs, the displacement method is recommended.

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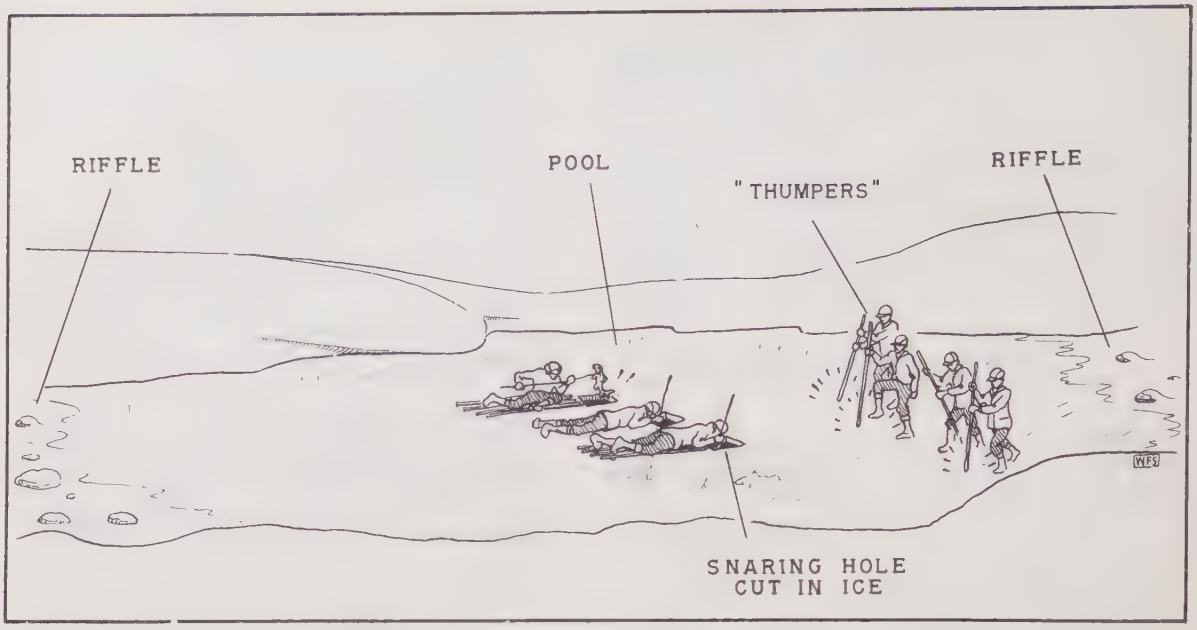
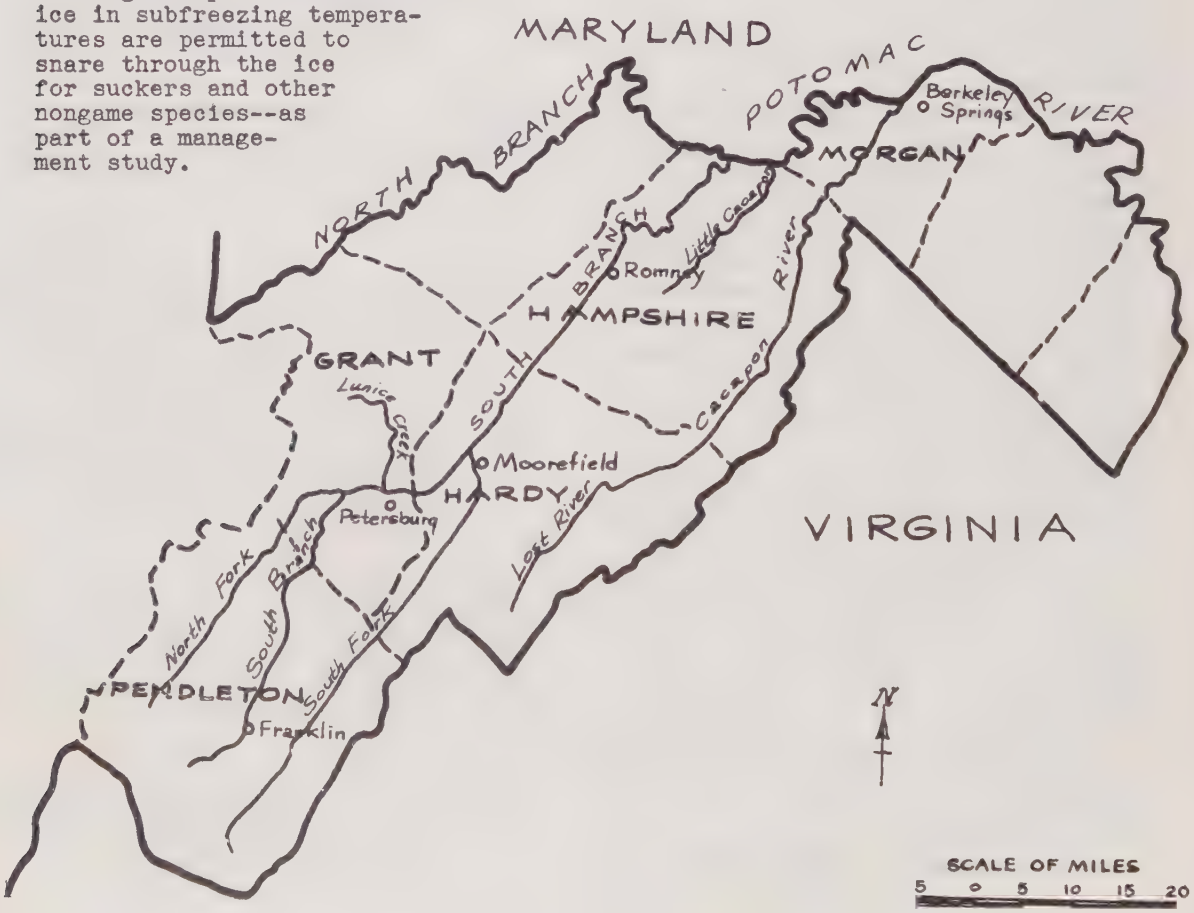


In five northeastern counties of West Virginia, anglers who are willing to spend hours on the ice in subfreezing temperatures are permitted to snare through the ice for suckers and other nongame species--as part of a management study.



SNARING THROUGH THE ICE FOR NONGAME FISH IN WEST VIRGINIA

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SNARING FISH through the ice is not legal in West Virginia, but it is allowed on an experimental basis in five counties for nongame species. Although the sport (art?) of snaring is written on the books as illegal, there are many persons who wish to angle in this fashion. Snaring is thoroughly ingrained into the habits of "residenters" of certain counties, and it is a practice which must be regulated--not prohibited, as was once decided by law-enforcement-minded individuals.

In 1948 the Conservation Commission of West Virginia set up a study of ice snaring for the purpose of obtaining sufficient data to set intelligent management regulations. Creel-census data were kept for January and February in 1948, when ice cover on streams permitted the sport. No snaring occurred in the winters of 1949 and 1950 because mild weather conditions prevented the formation of sufficient ice. When ice covers are suitable for further study of the snaring catch, a comparison of data will be made.

How Fish Are Snared

Fishing with various lures through the ice is not a new sport, and it is becoming more widespread. The snaring of fish, on the contrary, is less widespread, if not rare. Ordinarily one may think of Indians when snaring is mentioned. In West Virginia, however, those who participate in snaring are far from being Indians. All types of tradesmen or professionals in the small towns and villages located on the six streams under study engage in snaring fish through the ice. The sport attracts men in all walks of life, from the circuit court bench to the street-cleaning department.

The West Virginian generally uses a slender pole with wire attached. The pole is 3 to 4 feet in length and tapers from 1 inch to 1/2 inch in diameter. One end of the wire (usually 18-gauge copper) is firmly attached to one end of the pole; the loose end of the wire, of course, forms a noose.

West Virginians snare through the ice principally for suckers and fallfish. Snaring is accomplished by a number of men in a fishing party--seldom fewer than 3, occasionally as many as 38, but ordinarily 7 or 8 anglers. At the favorite stream pool, about three holes (generally 3 feet apart and 1 to 2 square feet in size) are chopped through the ice and cleared of floating ice chips. Once the holes are ready, three men take their places at these sites, kneeling or lying on planks or small platforms. All other individuals then congregate at one end of the pool, near the riffle. When the snares have been placed in the water, the men at the end of the pool begin making noises. They stamp, throw rocks, and beat poles on the ice at the riffle in order to scare the suckers and fallfish toward the open holes. This procedure is alternately repeated from the opposite riffle as the "thumpers" slowly move toward the snaring holes. The operator of a snare watches closely the movements of the fish, and as they swim near the hole, he manipulates the snare so that a fish will enter it. A quick upward jerk by the snarer closes the loop tightly around the midsection of the fish, which is then lifted to the surface. Duties are frequently switched so that each member of the party can have a chance at the holes.

TABLE 1.--Summary of stream catch records

Stream	Number of men on stream	Number of parties on stream	Average size of party	Number of fish taken	Average daily catch per angler	Number of fish per party	Number of fishing hours	Average fisherman day in hours	Fish taken per hour	Hours to catch one fish
South Branch, Potomac River	310	39	7.9	911	2.94	23.4	1,091	3.52	0.835	1.2
North Fork, South Branch, Potomac River	50	7	7.1	72	1.44	10.3	131	2.62	0.550	1.8
Cacapon River	50	6	8.3	122	2.44	20.3	274	5.48	0.445	2.2
Lost River	18	2	9.0	11	0.61	5.5	64	3.56	0.172	5.8
South Fork, South Branch, Potomac River	13	2	6.5	34	2.62	17.0	24	1.85	1.416	0.7
Little Cacapon River	5	1	5.0	4	0.80	4.0	20	4.0	0.20	5.0
Lunice Creek (South Branch, Potomac River)	4	1	4.0	None	-	-	2	0.5	-	-
Totals, Averages	450	58	7.8	1,154	2.56	19.9	1,606	3.57	0.720	1.4

Clear ice without a snow cover offers the best condition for successful snaring. Packed snow on the ice deadens the noise made by the party to drive the fish to the holes. Also, clear ice permits better observation of schools of fish. When there is no ice on the riffle or adjacent area, the snaring party will often throw rocks and logs into the water in order to frighten fish toward the holes.

Catches of fish are usually divided among the party members when they disband, regardless of who made the catches at the holes. Generally snaring parties start about 10 o'clock in the morning, and operations often continue until mid-afternoon.

Ideal snaring pools are 4 to 6 feet in depth and have little or no submerged vegetation. Needless to say, snaring is possible only when the ice is thick enough to support the snaring party. A bright sunny day is best. Large streams--such as the South Branch of the Potomac--which average 60 feet in pool width are most commonly chosen for snaring.

Catch Records

Conservation officers in four counties (Pendleton, Grant, Hardy, and Hampshire) kept snaring creel records. This involved six streams, as noted in table 1. These streams are tributaries of the Potomac River, draining the northeast panhandle area of West Virginia. They are typical smallmouth black bass streams. It should be noted that the greatest percentage of snaring took place in Pendleton County simply because streams in this county, being of the headwater type and having the highest elevation, held ice over a greater period.

Tables 1 and 2 present catch records by stream and by county, respectively. During the course of this study, 450 fishermen (see table 3), representing 58 snaring parties, were checked. They took 1,154 fish, of which 96.3 percent were white suckers and the remainder were hog suckers, carp, and fallfish (table 4). Most of the suckers taken were more than 12 inches long (table 5). This is to be expected because larger fish have a greater girth and thus are easier to snare. No fish of any species taken was less than 10 inches in length.

TABLE 2.--Catch records in the four counties

	County				4-county totals and averages
	Pendleton	Grant	Hardy	Hampshire	
Total number of fish taken	861	84	205	4	1,154
Average daily catch per angler	3.53	0.96	1.80	0.80	2.56
Total number of fisherman hours	805	149	632	20	1,606
Average fisherman day in hours	3.30	1.71	5.54	4	3.57
Hours to catch one fish	0.93	1.77	3.1	5	1.39
Average catch per party	26.9	6.5	17.1	4	19.9

TABLE 3.--Number of fishermen checked on each stream within four counties

Stream	County				Total
	Pendleton	Grant	Hardy	Hampshire	
South Branch, Potomac River	210	54	46	-	310
North Fork, South Branch, Potomac River	21	29	-	-	50
Cacapon River	-	-	50	-	50
Lost River	-	-	18	-	18
South Fork, South Branch, Potomac River	13	-	-	-	13
Little Cacapon River	-	-	-	5	5
Lunice Creek (South Branch, Potomac River)	-	4	-	-	4
Total	244	87	114	5	450

TABLE 4.--Species of fish taken by counties; over-all totals and percentages

Species	County				4-county total	Percent of total fish caught
	Pendleton	Grant	Hardy	Hampshire		
White suckers (Catostomus c. commersonnii)	828	82	197	4	1,107	96.3
Hog suckers (Hypentilium nigricans)	3	-	2	-	5	0.4
Carp (Cyprinus carpio)	-	1	4	-	5	0.4
Fallfish (Semotilus corporalis)	30	1	2	-	33	2.9

TABLE 5.--Length frequencies of species of fish taken

Species	Fork length in inches															Total
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
White sucker[1/]	27	72	115	83	77	65	62	14	18	11	6	1	4	-	-	555
Hog sucker	-	-	1	-	1	1	2	-	-	-	-	-	-	-	-	5
Carp[2/]	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2
Fallfish[2/]	1	1	10	9	4	3	-	-	-	-	-	-	-	-	-	28

[1/] Length measurements were not recorded on total take of white suckers in each county.
[2/] Length measurements were not recorded for all individuals taken during the study.

Discussion

Snaring through the ice is a successful method of catching nongame fish, especially suckers. The degree of success in the sport is not the prime factor for those participating in this type of angling. There is a real thrill involved, and the individuals who snare in West Virginia streams do so principally for the fun rather than for the meat. Snaring fish through the ice is as much an art to some anglers as fly fishing is to the trout angler.

This sport is illegal in West Virginia at this time. The laws prohibiting it were written by those who believed that the sport would be detrimental to gamefish production. This viewpoint undoubtedly is in error, as suckers are very prolific in the streams concerned and they are not likely to be depleted and thereby supply no young for bass food--as was claimed. Game fish are rarely caught by snarers. Suckers should be harvested. Anyone who cares to spend hours on the ice in subfreezing weather to engage in this sport perhaps should be permitted to do so as long as the sport is not harmful to the existing fish population.

Snaring through the ice for nongame fish in West Virginia is now permitted only on an experimental study basis.

Acknowledgments

Mr. Paul E. Swasey, former field fishery biologist for the Conservation Commission, is to be credited with compiling the data in this study. The data were obtained in the field through the cooperation of the following conservation officers: Earl A. Kidwell, Hansel Ruddle, Harrison Shobe, Owen D. Hughes, S. A. Saville, and District Conservation Officer John Shanholtz. Their help is greatly appreciated. Harry Van Meter, Assistant Division Chief, kindly made critical observations on the paper. The sketch was made by William Strunk, Staff Artist of the Division of Education and Publicity. The photograph is by Swasey.

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SULFAMERAZINE IN THE CONTROL OF COLUMNARIS IN STEELHEAD TROUT *(SALMO GAIRDNERII)*

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DURING THE summer of 1949, an outbreak of columnaris caused high mortalities in a group of fingerling steelhead trout (Salmo gairdnerii) held in hatchery troughs at the Coleman (Anderson, California) Station. This disease, which was first described by Davis (1922) as occurring in warm-water fishes, was also found by Fish and Rucker (1945) in fingerling blueback salmon at the Leavenworth (Washington) Station. Attempts by Fish and Rucker to control the columnaris by prolonged treatments with several external disinfectants were unsuccessful. Ordal and Rucker (1944) studied the myxobacteria causing columnaris and determined that the correct name of this organism was Chondrococcus columnaris (Davis). Slater (1948), working with chinook salmon infected with columnaris at the Coleman Station, found that the disease could be controlled with sulfamerazine. This drug was used in the following experiment to determine whether it would also be effective in arresting the course of the infection in the steelhead trout fingerlings.

The characteristic visible indication of the disease was a grayish-white area on the body of the fish, usually originating at the base of the dorsal fin (see figure) and spreading rapidly down the sides of the infected trout, often forming a distinct band an inch or more in width around the entire body before death took place. There was often a noticeable reddening of the skin at the edges of the lesion and around the vent and base of the anal fin when these areas were enveloped. Superficially, the lesions on the young trout appeared to be the result of a mild fungus infection, but microscopic examination invariably disclosed large numbers of the slender, motile, rod-shaped myxobacteria, C. columnaris. Similar organisms were recovered from cultures of kidney tissue and blood of several trout with external lesions. Fish with visible lesions apparently never recovered, as on three occasions 25 to 50 trout that had lesions were isolated in a trough, and each time all the fish died within 24 hours.

(Photo, U. S. Bureau of Reclamation)

Columnaris lesion on fingerling steelhead trout. Pencil indicates anterior edge of lesion.

When the mortality of the fingerling steelhead trout first became serious, the water temperature ranged from 60° to 68° F., the daily averages frequently reaching 65° F. During the course of the experiment, the water became cooler,

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Salmo gairdnerii is recognized by the American Fisheries Society as the scientific name of the rainbow trout (freshwater form) and of the steelhead trout (sea run of the rainbow).--The EDITORS.

its temperature ranging from 56° to 65° with a mean of 61.2° F.

The experiment was set up on August 8, and the first treatments were administered on the following day. Six troughs of fingerling steelhead trout averaging 85 per pound--troughs in which the mortalities were high--were selected for the test. These fish were placed in a single trough and were allowed to mix thoroughly. Then, with a Leavenworth sampler (Hewitt and Burrows 1948), the fish were divided into nine groups of approximately equal size and each group was placed in a standard deep trough. The nine troughs of trout were then arranged as three lots of three troughs each. The fish in Lot A and Lot B were treated with sulfamerazine. Lot C was the control group and was given no drugs or treatments during the entire experiment. The fish were fed twice daily, and half of the daily dosage of sulfamerazine was thoroughly mixed into each feeding. In addition to the sulfamerazine, Lot B was given pyridylmercuric acetate in a 1-hour prolonged treatment at a concentration of 1:200,000 on the first and second days of the experiment and again on the eighth day. As the pyridylmercuric acetate had no noticeable effects on the mortality, these treatments were discontinued after the third had been administered.

The percent mortality in each of the three lots of fish and the mean water temperatures by weekly periods are given in table 1.

The fish in Lots A and B were given sulfamerazine at the rate of 12 grams per day per 100 pounds of fish during the first week and at the rate of 6 grams per day per 100 pounds of fish during the second week. This 14-day series of treatments produced excellent results: the mortalities in Lot A and Lot B dropped to normal, while mortalities in Lot C, the untreated group, remained high. After the drug was removed from the diet at the end of the second week, the low losses continued for 4 days, but by the end of the third week of the test the mortalities in the previously treated fish were higher than at the start of the experiment. In this period the mortalities in the control troughs reached a peak.

At the beginning of the fourth week, sulfamerazine was again added to the food of Lots A and B for a 14-day period. Lot A was given the drug at the same rate as during the first series of treatments (namely, 12 grams per day per 100 pounds of fish for the first week and 6 grams per 100 pounds for the second week), while Lot B was fed sulfamerazine at the 6-gram rate for the entire 2-week period. In Lot A, the results of this second series of treatments were similar to the results obtained in the first series. By the end of the first 7 days of treatment, the mortalities in all three troughs of Lot A had dropped sharply; and during the following 7 days, only one fish died in this lot. Lot B, which received the lesser amount of the drug, also had a reduction in mortality, but the reduction was not so pronounced or complete as in Lot A. During the seventh and final week of the test, both lots were fed sulfamerazine at the 12-gram rate and the mortalities returned to normal. During the final 2 weeks, the losses of the control fish declined until they were lower than in

TABLE 1.--Percent mortality of steelhead trout and mean water temperatures by weekly periods

	Percent mortality								Original number of fish
	1st week	2d week	3d week	4th week	5th week	6th week	7th week	Total	
Drug	sulfa	sulfa	-	sulfa	sulfa	-	sulfa		
Lot A	3.9	0.4	3.1	7.1	0.04	2.7	1.1	17.1	3,148
Lot B (PMA)	3.3	0.3	2.1	6.3	1.2	3.7	1.2	17.0	3,302
Lot C (control)	4.5	7.9	10.7	4.4	1.6	1.6	0.4	27.5	3,111
Mean water temperature, °F. ..	62.0	61.7	61.0	63.2	60.3	60.2	59.4	61.2	

either of the treated lots. It is thought that this reduction was the result of a combination of lowered water temperatures and the previous death of the more susceptible individuals in the lot.

Although the mortality during the experiment was 10 percent less in both the treated lots of fish than in the controls, it is possible that if the sulfamerazine treatments had been continued for longer than the 2-week periods, the beneficial effects would have been greater and a permanent cure might have been achieved. Even at the end of the test, most of the dead and moribund fish in Lots A and B had the external lesions characteristic of the disease.

This hatchery is supplied with water from a creek which contains a population of salmon, trout, and scrap fish. These fish may provide a source of infection for the hatchery stock whenever the water temperature is suitable for the rapid growth of the bacteria. Hatchery fish which have visible external lesions are beyond help and should be removed as soon as possible to lessen the danger of infection from this source.

The results of this experiment indicate that sulfamerazine administered in the food at the rate of 12 grams per day per 100 pounds of fish for 7 days and at the rate of 6 grams per 100 pounds of fish for the succeeding 7 days, caused a temporary reduction in the mortality among fingerling steelhead trout infected with columnaris but did not eliminate the infection. Sulfamerazine treatments at the 6-gram rate for 14 days appeared to be less efficacious than treatments at the higher rate. The drug is effective but must be used continuously at high levels to keep a columnaris infection in check.

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Our salmons, shads, river herring, striped bass, and sturgeons are known as anadromous fishes, going from salt water to fresh water to spawn: the common fresh-water eel (Anguilla rostrata) is the only American fish recognized as a catadromous fish, migrating from fresh water to salt water to spawn.

AN IMPROVED CORDAGE FOR LIMNOLOGICAL HAND LINES

When used in making depth soundings or in raising and lowering limnological apparatus commonly employed in fishery lake surveys, graduated hand lines of cotton sash cord are frequently troublesome because they shrink and stretch unpredictably. Despite care in shrinking and stretching the sash-cord lines prior to field use, errors as great as 10 percent have been encountered in depth measurements. Metal lines are generally impractical for hand use.

Dr. Frank F. Hooper of the Department of Zoology, University of Michigan, Ann Arbor, points out that a plastic-covered fibre-and-wire cordage known as Kordite has certain advantages over other cordages for use in making all-purpose graduated hand lines. He lists the following advantages of Kordite:

1. It is waterproof and does not stretch appreciably.
2. It can be permanently graduated with markings that are easily read.
3. It is highly resistant to concentrated acids which may accidentally be spilled on lines during field work.
4. It permits apparatus to be raised and lowered repeatedly with greater rapidity, ease, and comfort than are possible with cotton sash cord, metal lines, or hemp ropes.
5. It is comparatively inexpensive.

Two weights of this cordage are being widely marketed: a clothesline with a tested breaking load (in air) of 362 pounds, and a sash cord with a tested breaking load of 464 pounds. For both weights, the tested elongation with a load of 150 pounds is 2 percent.

Dr. Hooper reports that the clothesline is perhaps most suitable for routine limnological work. Although less flexible than cotton sash cord, the Kordite clothesline can be tied into knots and coiled without danger of kinking. According to Dr. Hooper, permanent graduation markings can be made by applying to this line a saturated solution of Sudan 4 in Isophorone with a small camel's-hair brush. "Lines given hard field use for a period of 9 months show no signs of deterioration and have proved highly satisfactory in every respect."

EXPERIMENTS WITH CANNED FISH AS FOOD FOR TROUT

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THERE WOULD appear to be certain obvious advantages in the use of canned products in feeding trout, especially if it were possible to develop a product which would supply all the nutritional needs of the fish and could entirely replace the raw meats that now form the mainstay of our diets. Besides the readily apparent advantages (ease of storage, elimination of refrigeration facilities, and ease of processing), there would appear to be a special advantage if cheap marine fish could be used in this way, for this might provide a means of escaping some of the seasonal price rises which affect all of our usual hatchery meats.

At the Rome hatchery, there have been a number of desultory attempts to feed canned fish to small lots of trout. None of these attempts has proved encouraging, for relatively poor growth has always resulted. A binder, in the form of a cereal or dry skim milk, was included in all these trials, as the plain canned fish proved too brittle and dispersive for good feeding. Several species of fresh-water fish, including carp which was canned for us by a dog-food manufacturer, were tried.

Some time ago we were approached by a commercial fish-canning concern that was interested in the possibility of using canned whole mackerel and yellowtail as trout food. We secured 2 tons of this product, canned especially for us to include 88 percent fish and 12 percent oatmeal (no water was added). We then proceeded to run some tests, which will be the subject of the present report. It should be remembered that when canned fish is mentioned hereafter, the fish-and-oatmeal product is meant.

Four lots of rainbow trout fingerlings were fed the canned fish with various modifications, and a fifth lot was maintained on a diet of edible beef liver for comparison. There were 175 fish in each lot at the start of the test. Each lot was kept in a trough supplied with water direct from the spring. All lots were fed according to the feeding charts of Deuel and Tunison (1944), and all were weighed once a week.

Growth will be reported in terms of weekly increase in the cube root of the average weight per fish in grams, which Haskell (1948) has shown to be a constant quantity in normally growing fish.

The first part of the test consisted of a 5-week run of the following diets: Lot 1, edible beef liver; Lots 2 and 3, 90 percent canned fish and 10 percent dry skim milk; Lots 4 and 5, canned fish.

Throughout the 5-week period, the liver-fed group made the best growth; the fish-plus-milk groups, the next best; and the fish groups, the worst. The average weekly increase in the cube root of the weight (multiplied by 1,000 to reduce decimals) appears in the first section of table 1.

Since the poor showing of the fish-fed lots confirmed our previous experiences, it was decided not to continue all these diets, but to modify them in an effort to find out what could be added to canned fish to improve its growth-promoting properties. No raw meats were used because we were interested in getting away from a dependence on such products.

For the following 9-week period, while the diets of Lots 1, 2, and 5 were unchanged, the diets fed to Lots 3 and 4 were modified as shown in the middle section of table 1. The middle section of the table also shows the average weekly increase in the cube roots of the weights for these five diet-groups in the 9-week

TABLE 1.--Growth of trout on canned fish diets, expressed as weekly increase in cube root of weight

Lot	5-week period		9-week period		4-week period	
	Diet	Weight gain	Diet	Weight gain	Diet	Weight gain
1	Beef liver ...	45.4	Beef liver ...	44.7	Beef liver ...	47.8
2	Fish ..... 90 Milk 10	38.4	Fish ..... 90 Milk 10	22.3	Fish ..... 80 Milk ..... 10 1/ Penicillin mat . 10	21.5
3	Fish ..... 90 Milk 10	34.0	Fish ..... 85 Milk ..... 10 Yeast 5	30.9	Fish ..... 85 Milk ..... 10 Yeast 5	33.2
4	Fish	20.2	Fish ..... 85 Milk 15	27.4	Fish ..... 70 Milk ..... 10 Yeast ..... 10 Cottonseed meal 10	36.5
5	Fish	25.8	Fish	10.9	Fish ..... 80 Milk ..... 10 Yeast 10	47.2

1/ Penicillin mat consists of dried, ground penicillium mycelium, a by-product in the manufacture of penicillin. It is similar to yeast in protein and vitamin content. The mat used in this test was kindly donated by Bristol Laboratories Inc., of Syracuse, New York.

period.

Comparison of the weight-gain data for the 9-week period with the data of the 5-week period, indicates that none of the fish diets produced as good growth as did the liver. Furthermore, Lots 2 and 5, though continued on the same diets as in the first period, made poorer growth, indicating that the deficiency of both their diets was not fully revealed in the first, brief 5-week test. The addition of yeast to the fish-milk diet (Lot 3) resulted in the best growth, and a supplement of 15 percent milk (Lot 4) produced better growth than a supplement of 10 percent milk (Lot 2).

At the end of 9 weeks, the diets of Lots 2, 4, and 5 were changed again. For the next 4 weeks, the third part of this experiment, the diets of Lot 1 and Lot 3 (which had made the best showing) were continued without change and the diets of Lots 2, 4, and 5 were modified as shown in the third section of table 1. The growth rates on these diets also are given in the third section of the table.

Examination of the data for the third period shows that the addition of 10 percent dry skim milk and 10 percent dried brewers' yeast improved the canned fish so that it produced growth as good as that produced by the beef liver. The penicillin mat was apparently useless, as the growth of Lot 2 was not so good during the final period as it had been in the preceding. This, however, may not really reflect the true nutritive value of the penicillin mat. The mat does not help bind a food mixture, whereas the yeast does to a slight extent. The superior performance of the yeast may be due largely to its slight gumminess. Addition of cottonseed meal did not improve the diet, as may be seen by comparing Lot 4 and Lot 5.

Throughout the first two periods of the experiment, the mortality in all lots was low and of no significance. During

the final 4-week period, however, losses rose in the four groups receiving canned fish, so that by the end of the fourth week the total losses for the period stood as follows: Lot 1, 1 fish; Lot 2, 30 fish; Lot 3, 26 fish; Lot 4, 32 fish; and Lot 5, 22 fish. Obviously, in the four fish-fed groups the mortality was lowest in Lot 5, which also made the best growth. Nevertheless, though the growth in Lot 5 was as good as in the liver-fed lot, the losses in the former were very much higher. No effort was made to determine the specific cause of the mortality, but it was noted that there was no gill disease present.

During the period covered by the experiments which have been described here, another New York hatchery attempted to feed the same canned fish product with supplements of dry skim milk and of 30 percent pork melts. This attempt was on a larger scale and involved two whole ponds full of fingerling brook trout. These experiments will not be described in detail. It need only be said that the results were disappointing, and the diets were discontinued after 1 month. Poor growth and conversion were obtained, but no increase in mortality.

Summary

A canned fish product consisting of 88 percent marine fish and 12 percent oatmeal was fed to fingerling rainbow trout. The product was fed by itself and with various amounts of dry skim milk, dry brewers' yeast, cottonseed meal, and penicillin mat.

The straight canned product produced poor growth, compared to the growth produced on a diet of edible beef liver. Some of the modifications improved the diet, the best growth being obtained through an addition of 10 percent milk and 10 percent yeast. During the last 4 weeks of the experiment, mortality was high in all the fish-fed trout.

The canned fish also produced poor growth in a 4-week trial with two ponds full of brook trout.

On the basis of the results obtained, it appears that plain canned fish, or fish-cereal mixtures, cannot be used to advantage as the food of trout unless supplemented with other products. A fully satisfactory supplement was not found.

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The study of key scales of marked lake trout recovered from the Lake Michigan plantings of 1944-46 may be expected--because these fish are of known age--to serve the dual purpose of checking the validity of the annulus as a year mark and of providing data on the body-scale relationship.

USE OF SHIELDING CABLE IN ELECTRIC FISH-SHOCKING DEVICES

At the suggestion of a local electrician, Dr. Dwight A. Webster and associates in the Department of Conservation at Cornell University, Ithaca, New York, recently experimented with 1/2-inch shielding cable as a floating electrode employed in connection with AC generators and a grounded system. The grid used in this experimental work was 30 feet long; the plastic gill-net floats which buoyed up the grid were 1-5/8 by 4-5/8 inches. The electrode was used with generators of 500- and 2,500-watt capacities.

After a season of trial by Cornell University, as well as by the Western Fisheries District of the New York State Conservation Department, a number of distinct advantages in the use of shielding were apparent. Principal among these advantages were lessened resistance of the electrode to current drag, virtual elimination of breaks, and better conductivity resulting in greater shocking power.

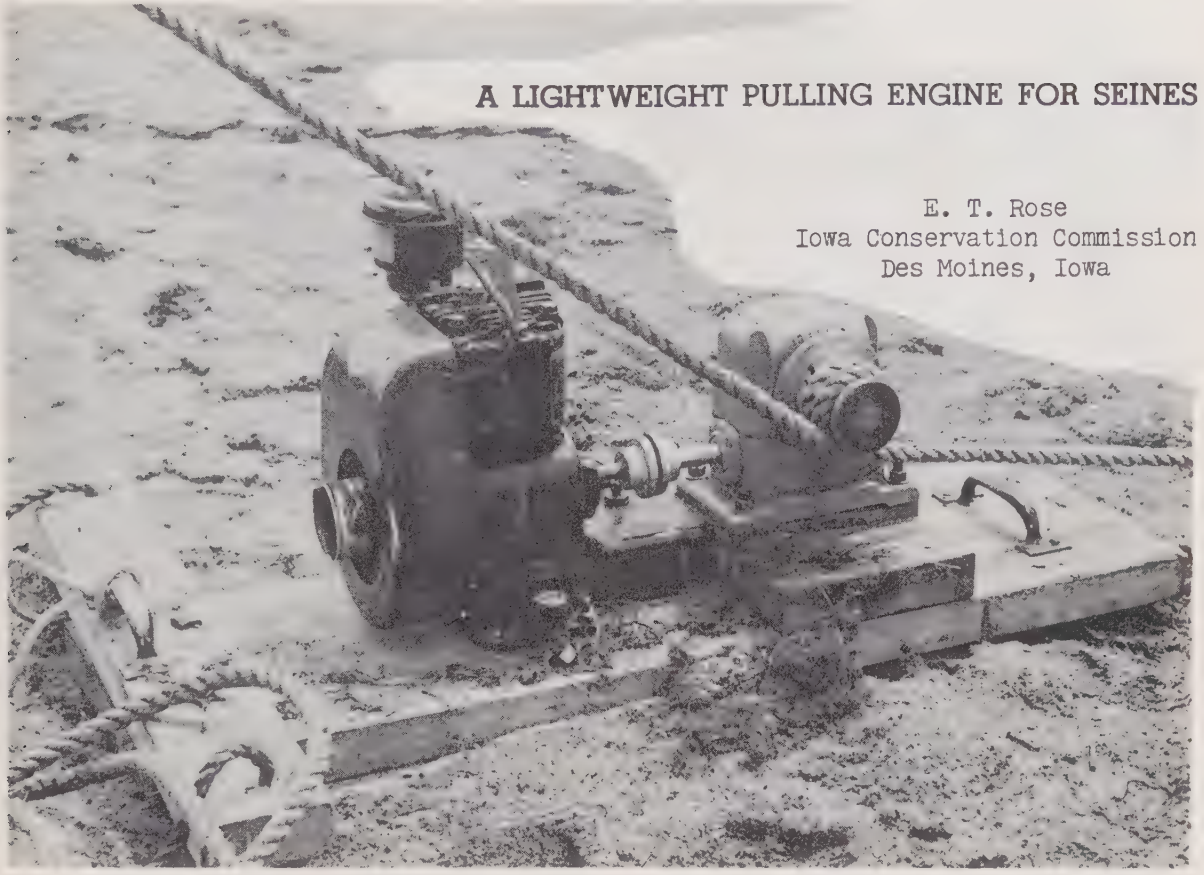
Though the electrode used was continuous, the material could be adapted for use in the "electric seine" type of electrode or for use in those devices involving alternate sections of positive and negative charge. For the latter type, all connecting wires could be run through the shielding in the conventional manner, forming a neat unit of gear that would do a minimum amount of snagging.

The shielding cable has also been used as a floating ground in connection with DC generator units. Reporting upon the favorable results obtained with this material, Dr. Webster pointed out that about 6 feet of cable, held in the center by a battery clamp connected to the negative pole, proved adequate in small streams.

An enormous head, no body, no scales, no tail--not even the suggestion of a tail fin--the ocean sunfish should be a natural for the comic strips. Specimens more than 8 feet long (across?) and weighing 1,200 pounds have been reported. Such a great head, moving lazily along near the surface, perhaps with its dorsal fin projecting above the water, should rouse as much interest in comic-book readers as any of the currently popular freaks.

A LIGHTWEIGHT PULLING ENGINE FOR SEINES

E. T. Rose
Iowa Conservation Commission
Des Moines, Iowa



(Photos by Jim Sherman, Iowa State Conservation Commission)

THE IOWA Conservation Commission uses a 500-foot seine (1/4-inch bar mesh) to obtain data on young-of-the-year fishes in its lake surveys and annual inventories. This drag-seine, though relatively short, is 15 feet deep in the bag section and usually requires a six-man crew for its operation. Much hard labor is encountered in lakes that have soft, muddy basins, or in lakes that have heavy blooms of blue-green algae which clog the meshes of the seine. In these areas it is extremely difficult to haul the seine with a full crew and often with several volunteer helpers.

To eliminate much of the hard labor, a light-weight motor-driven winch has been devised. This has proved very efficient and economical. The unit, as shown in the accompanying photographs, consists of a 3/4-horsepower 4-cycle engine (2,300 revolutions per minute) which drives a 40 to 1 reduction gear. The engine and reduction gear box are directly connected, so that the necessity for a clutch, belts, or pulleys is eliminated. A customary spindle or "cat-head" is keyed to the axle of the reduction gear, around which the pulling rope, or sea-line, is wrapped during operation. The cat-head revolves at about 1 revolution per second, which is about ideal for our purposes. With this machine, the seine can readily be operated by a five-man crew or less--a reduction in costs and in the heavy labor that was previously required.

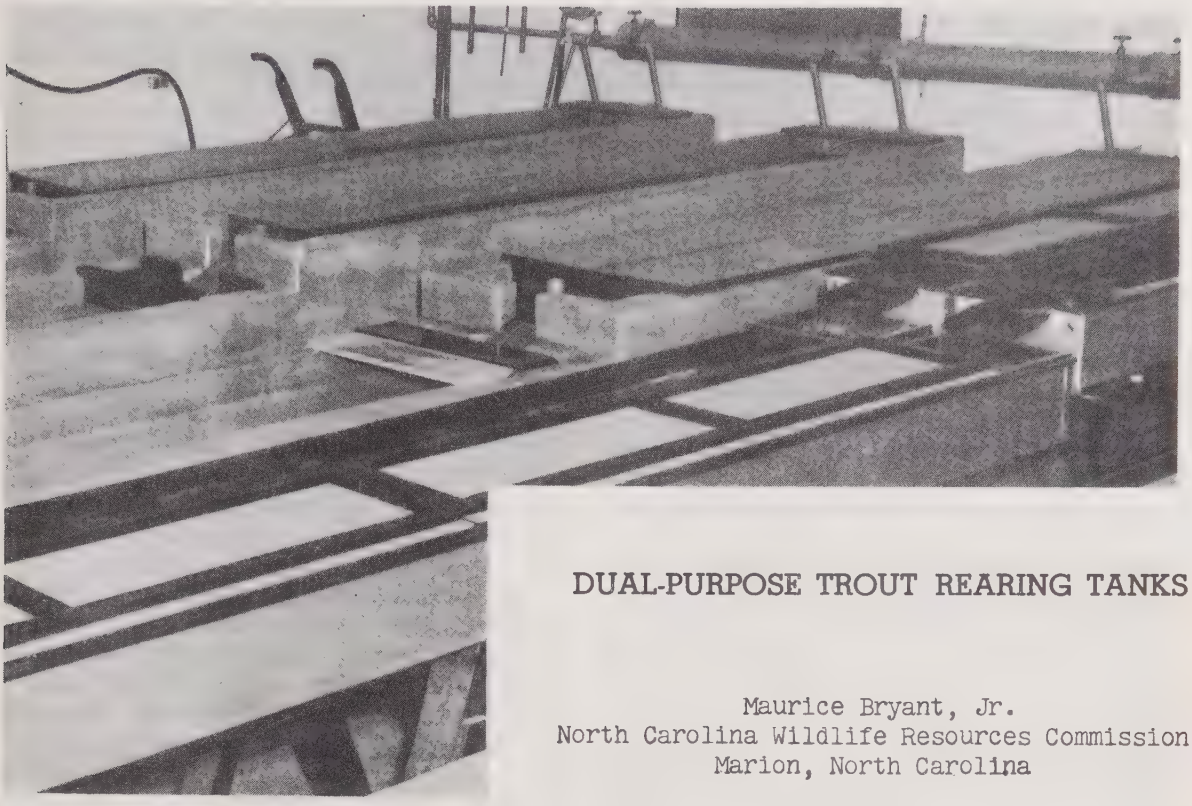
A description of its use follows: As soon as the seine is laid out from the barge, the pulling engine is anchored on shore and the brails are pulled to the water's edge. Each of the brail lines on our seine is 100 feet long. One end of the seine is then staked to shore, and the pulling engine is used to haul

the other end. When the brail end is brought to shore, the engine is taken 40 to 60 feet down shore and the rope from it is tied to the seine 100 feet from the end. The engine pulls this 100 feet of seine while two men keep it coming in smoothly and pile it along shore. Then the engine is moved down shore another 40 to 60 feet and a rope is attached 100 feet farther along the seine--where the bag portion starts. When this end of the bag is brought to shore, the engine is moved to the other end of the seine and the process is repeated. The 100-foot bag section is then readily hauled in by hand. One man operates and transfers the engine from one location to another along the haul, leaving the rest of the crew to manipulate the seine and set brails. The pulling engine weighs only 70 pounds and can readily be carried by the operator to each location, anchored, and put in operation without having the motor stopped.

It is believed that this labor-saving device could readily be applied to many seining operations, particularly where portability and ease of handling are desired. For use with heavy tackle (2,000 feet of seine or more) a 1½- or 2-horsepower motor could be substituted to obtain more power, and the unit could be mounted on a barge if desired. No data concerning the exact pulling power of our unit are available; in a "tug-of-war" test, however, five men were required to pull against it with full force before producing engine labor.

Complete and assembled, our unit cost in the neighborhood of $100. A good machinist can make the steel spindle or cat-head and obtain the reduction gear from his supply house. Various combinations of engine sizes and gear ratios may be obtained to fulfill a variety of requirements, but for our purposes the unit as described could scarcely be improved.

In the fall of 1950, the California Division of Fish and Game placed tatoo marks on the tails of a group of 5-inch salmon. Using a code system of three variable dots and seven different colors, fishery workers tatooed the young salmon at the rate of 25 an hour. To test the reliability of the system wherein age and length estimates have been based upon fish scales, these tatooed salmon will be measured at various ages and individual records will be compared with estimates made on the basis of scale growth.



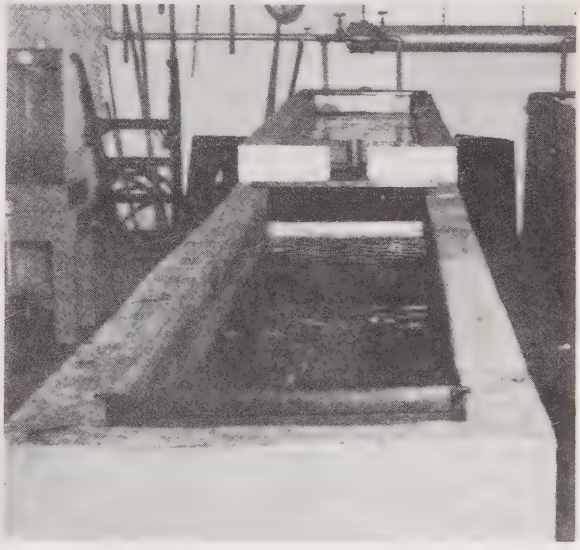
DUAL-PURPOSE TROUT REARING TANKS

Maurice Bryant, Jr.
North Carolina Wildlife Resources Commission
Marion, North Carolina

THE URGENT need for added rearing space for trout fingerlings at the Marion Fish Hatchery of the North Carolina Wildlife Resources Commission brought about the construction of six dual-purpose rearing tanks on a trial basis in the spring of 1950. The use of this particular type of tank is believed to offer a desirable innovation to accepted hatchery practice. The results obtained while these tanks were used last season were such that it appears desirable to suggest similar construction to hatcherymen with similar problems.

The added space was needed because the Marion Fish Hatchery serves as the hatching center for three other stations where the winter water temperatures and other conditions are less suitable for successful hatching and early growth. This puts a tremendous load on the available rearing facilities.

It had been determined that a stream temperature differential of 20° F. between the water supply at Marion and at the other stations was not conducive to the successful transfer of fingerlings between hatcheries before the first of April.



(Photos courtesy North Carolina Wildlife Resources Commission)

Consequently, additional space for holding small trout was a primary consideration. It was considered desirable to hold the fish indoors under more close supervision and care than are normal in large outdoor rearing pools. Evidently, the only way to accomplish this was to use the wasted space under the standard hatching troughs in the hatchery building.

Under each set of two hatching troughs were constructed two cement tanks, their walls of such height that the tops would serve as support for the rearing troughs when placed in their normal positions. The tanks, therefore, were in a series of lengthwise pairs, providing two levels as with the hatching troughs. The tanks were constructed of steel-reinforced concrete, with 5-inch walls and with the bottoms poured directly on the floor of the hatchery building. The center or dividing wall between each pair had a notch 6 inches wide to permit water flow between the upper and lower sections. This opening was fitted with a wooden baffle to prevent the fish from jumping from the lower to the upper section. Each section was provided with tail-screen slots just ahead of the drain.

At the start of the hatching season, the troughs were set on top of the tanks and held in place by 1-inch angle-iron frames with a center bar of steel to prevent sagging. After the fish hatched and grew to approximately 1-1/2 inches in length, the troughs were removed for storage during the summer and the fish were placed in the tanks for rearing until they could be transferred successfully to other hatcheries.

The tanks are dual-purpose in that they serve as racks or standards for the regular hatching troughs during the hatching and early feeding period, and then provide more rearing space as the fish continue to grow. Thus the hatcherymen hold the fish indoors under immediate control for at least a month longer than before. Because the space, water flow, and drains required for the troughs and the tanks are the same, a considerable saving in the cost of construction is effected. The tanks, providing their added volume of rearing space, double the carrying capacity of the hatchery building.

In addition to the benefits of rearing space at low construction cost and the extended control factor, another major benefit from these tanks became evident. Fish held in the tanks under the same conditions of weight concentration per cubic foot of water, gallons per minute of flow, water temperature and quality, and fed the same amount of food in percentage of body weight, consistently showed from 15 to 20 percent more growth per month than the fish held in standard hatching and rearing troughs. This provided an early and desirable development in size before the fish were transferred to the colder waters of other stations.

In studies involving the interrelations of species, the incomplete collection of data by seining could lead to grave misconceptions where a great part of the standing fish crop is composed of such "unseinable" species as eels.

THE FISHERY SESSIONS OF THE 4TH ANNUAL CONFERENCE OF SOUTHEASTERN FISHERY AND WILDLIFE WORKERS

John Marshall Hotel, Richmond, Virginia
October 15-18, 1950

John F. Dequine
Game and Fresh Water Fish Commission
Tallahassee, Florida

SOUTHEASTERN fishery and wildlife technicians have been meeting annually with the Southeastern Association of Game and Fish Commissioners since 1947. Meetings have been held at St. Petersburg, Florida, in 1947; at Lexington, Kentucky, in 1948; and at Nagshead, North Carolina, in 1949. The 1950 meeting in Richmond, Virginia, was the fourth such meeting. The technical programs have generally been divided into the fishery and wildlife sessions, the Southeastern Section of The Wildlife Society doing most of the planning for the game sessions and committees of State fishery workers usually planning the fishery sessions. Regular participants in the Southeastern Conference have been the States of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia, as well as various Federal services and educational institutions. Texas, Pennsylvania, Ohio, West Virginia, and several other States have also sent representatives to some of the meetings. Attendance this year was estimated at 200.

As the fishery sessions have always avoided the presentation of formal papers, the results of these meetings and discussions have not heretofore been generally available to those who could not attend. Scientific fish (and game) management has made great strides in the southeast since World War II, and all the States are now sponsoring (either directly or indirectly) fishery investigations which should be of interest to workers in other sections. This report was prepared to make available a summary of the subjects considered at the 1950 meeting, and particularly to make known the names and locations of the fishery workers and the problems with which they are concerned. Some of the authors prepared mimeographed copies of their discourses, and those designated on the following pages by an asterisk are available either from the author or from the Secretary of the Southeastern Section of The Wildlife Society (Mr. Ed Hueske, U. S. Fish and Wildlife Service, Atlanta, Georgia).

This year's fishery sessions were planned by the Committee on Fish Sessions: Dean A. Rosebery of Virginia, chairman, Charles J. Chance of Tennessee, and John F. Dequine of Florida. At least 60 southeastern fishery workers and other interested persons attended and took part in the general discussions. The program topics and discussions are summarized briefly here. Those who desire more detailed information should contact the authors of the individual papers.

The Use of PMA in Treating Columnaris

Maurice Bryant
Wildlife Resources Commission
Raleigh, North Carolina

An attack of columnaris (Cytophaga columnaris) caused severe mortality among fingerling brown and rainbow trout at the State hatchery in Marion, North Carolina,

during the summer of 1950, when water temperatures rose to 68° F. or higher. Biweekly treatments with pyridylmercuric acetate at rates of 1:150,000 for brown trout and 1:400,000 for rainbow trout were effective in reducing mortality rates to "normal." Length of exposure to treatment averaged about 35 minutes for rainbow trout and 45 minutes for the brown. Experimentation revealed that the length of time between treatment of and reinfestation with the disease was directly proportionate to the strength of the solution--that is, higher concentrations gave longer relief.

An exception to any complete success occurred when one lot of rainbows was killed by a treatment of 1:150,000 at the end of the season, although they had successfully withstood similar treatment previously. A sudden increase in pH and a decrease in temperature occasioned by heavy rains were suggested as possible explanations for the difference in the effect of the PMA in this instance, as no other major environmental changes were observed. Treatment was found unnecessary when water temperatures dropped below 65° F.

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*How To Tell Ulcer Disease from Furunculosis in Trout and Methods of Treatment of These Diseases

S. F. Snieszko and S. B. Friddle
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

Considerable confusion exists in distinguishing between furunculosis and the several types of ulcer disease that occur in hatcheries producing salmonid fishes. Though the bacterium causing furunculosis (B. salmonicida) has been isolated and well known for many years, it is only recently that Hemophilus piscium, one of the organisms causing ulcer disease, has been isolated and described.

The two diseases can sometimes be distinguished by inspection and dissection; unfortunately, positive diagnosis, on which proper treatment depends, can be made only by bacteriological examination.

Treatment for furunculosis, already covered in other papers, can be omitted in this summary. No satisfactory treatment for ulcer disease has yet been found, although "Terramycin," one of the new antibiotics, holds promise.

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*Pollution Studies on the Shenandoah River

Croswell Henderson
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

The Shenandoah River in northern Virginia and eastern West Virginia was an excellent fishing stream before it received industrial wastes from a rayon mill and a chemical plant after 1941. Between then and 1945, however, many dead fish were observed, fishing was almost eliminated, and bottom food organisms decreased as much as 97 percent in test areas. The united efforts of local and national sportsmen's groups, together with the help of State and Federal conservation agencies, brought about a change for the better. Soluble zinc was found to be a major toxic substance.

The offending companies took steps to recover the zinc and other pollutants in 1947, and improvement became noticeable in the summer of 1948. Conditions have improved steadily since then and are now approaching those of pre-pollution days. Bottom insects have gained in abundance; minnows have recovered their former abundance; bass, sunfish, fallfish, suckers, carp, and catfish have reappeared in most of their former habitat. Except in a few limited areas, the Shenandoah River is again providing recreation in the form of successful fishing trips.

Spawning Grounds of the Striped Bass in Virginia

E. F. Tresselt
Virginia Fisheries Laboratory
Gloucester Point, Virginia

This report, presented by W. H. Massman in Mr. Tresselt's absence, described the

Virginia Fisheries Laboratory's recent research on the spawning habits of the striped bass. Spawning areas, formerly ill-defined, were located in the following Virginia rivers: Chickahominy, James, Pamunkey, Mattaponi, and Rappahannock. Eggs were collected in nylon plankton nets held stationary--in a manner similar to an airfield's windsock--in the current in suspected areas. Collection of striped bass eggs was about five times more successful near the surface than at the bottom. Initial studies indicate that a major amount of spawning occurs in the turbid waters just above the brackish water line, in much the same areas from which commercial fishermen report their best catches.

Shad Reproduction in Virginia

W. H. Massman
Virginia Fisheries Laboratory
Gloucester Point, Virginia

The Virginia Fisheries Laboratory investigated the spawning habits of the American shad simultaneously with the striped bass studies. It was found that shad spawned in the following Virginia rivers: Pamunkey, Mattaponi, Chickahominy, James, Appomattox, and Rappahannock. In contrast to the eggs of the striped bass, the largest number of shad eggs was collected while the nets were stationed on the bottom. Almost all shad eggs were taken in the channels in areas of no salinity, upstream from the areas most frequented by the striped bass. Time of day and temperatures apparently had little effect, as newly spawned eggs were taken from 42° to 75° (F.) water at all hours. Two-thirds of the eggs collected were dead.

Mexican Fish Ponds

H. W. Jackson
Virginia Polytechnic Institute
Blacksburg, Virginia

Dr. Jackson presented an extremely interesting report of a year's investigation of Mexican fish ponds, amply illustrated by color slides. This information is being summarized for presentation in a future issue of THE PROGRESSIVE FISH-CULTURIST; therefore, no synopsis is presented here.

Creel Census Studies on Eastern Tennessee Streams

Willis King and Warren Currier
Tennessee Division of Game and Fish
Nashville, Tennessee

Between May 16 and August 31, 2,467 fisherman days were recorded on Little River, Great Smoky Mountains National Park, above the creel station, on about 12 miles of fishable water. The catch consisted of 11,304 rainbows and 796 brook trout. The creel of successful anglers averaged 7.3 fish weighing slightly over 1 pound. Approximately one-third of the anglers caught no fish. Of 500 brook trout stocked in the area covered by the census, 306 (61 percent) were recovered by anglers. Post-season examination of three sample sections of stream revealed a good population of rainbows remaining. Rainbows are in complete dominance except in headwaters where native brook trout occur.

Discussion:

Value of Creel Census as a Fisheries Management Tool

Leader:

John F. Dequine
Game and Fresh Water Fish Commission
Tallahassee, Florida

An outline of factors to be considered and data to be sought in designing a creel census was presented. Summarized, the presentation and discussion established that primary or immediate aims of a well-designed creel census were total production or yield and fishing success; that secondary or long-term aims were species composition, fishing intensity, species

requiring major management effort, effect of management practices, and biology of the fishes; that tertiary aims were the economics of angling, effectiveness of types of bait, time of day, season, age and sex of anglers, concentration of fishing areas, and others.

The type and scope of a creel study must also involve the quality and quantity of personnel: a trained, personable technician obviously is able to obtain much more thorough and comprehensive data than the regular game warden with numerous other duties to occupy his time. To be avoided are the collection and compilation of relatively unimportant data which are not essential to the management of the fishery but which consume the time and manpower more needed in increasing the statistical significance of those data concerned with the primary aims.

Summarization and Discussion of the Technical Papers Presented at the 1950 American Fisheries Society Meeting

A. H. Wiebe
Tennessee Valley Authority
Norris, Tennessee

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*Fish Reproduction, Growth, and Fishing Success during the First Season in Allatoona Reservoir

E. E. Hueske
U. S. Fish and Wildlife Service
Atlanta, Georgia

Samples taken by seines and rotenone in Allatoona Reservoir, a recently completed multiple-purpose impoundment on the Etowah River north of Atlanta, Georgia, revealed striking differences in the pre- and post-impoundment fish populations. Reproduction of crappies, black basses, and carp was especially successful during the first year of impoundment, although of these species only the basses were present in appreciable quantities in the pre-impoundment samples. Catfishes, redhorse, and suckers made up 74 percent of the sample before, but only about 8 percent of the small fish recovered after impoundment were of these species.

The catch by anglers during the first 2½ months of fishing was 48 percent carp, 34 percent black bass, and 18 percent of others (mostly bluegill and channel catfish). Eighty-seven percent of all anglers caught fish during this period, but the average catch per trip was considered low--about 11.6 ounces.

Useful Tools in Pond and Lake Management for Warm-Water Game Fishes

Ancil Holloway
U. S. Fish and Wildlife Service
Atlanta, Georgia

The most useful tool in managing ponds and lakes in southeastern United States was concluded by Mr. Holloway to be a well-trained fishery technician, able to apply practical methods of obtaining combinations of species and sizes which would result in the production of the maximum number of successful fishing trips from a given body of water. These desirable combinations were outlined, and methods of obtaining them were discussed.

Discussion: Fisheries Management Problems

Leader:

H. S. Swingle
Alabama Polytechnic Institute
Auburn, Alabama

Definitions of various groups within fish populations were given, and data gathered by rotenone on some of these groups from two portions of the Coose River in Alabama--from Lay Impoundment, a dammed-up portion of the river, and from the main stream some distance below the dam--were presented.

Considerable differences in species composition ("E" values) were noted in the separate areas, as could be expected. For example, catfishes, drum, buffalo, and other bottom feeders were predominant in both the shallow and deep mainstream

areas sampled (more than 90 percent of total weight), while this same group made up only 17 and 50 percent, respectively, in a pocket and an open-water area of the impoundment. Gizzard shad, an insignificant part of the river population, comprised the major single species in the impounded areas. Game fish (basses, crappie, and bream), representing less than 5 percent in the river, made up 22 and 17 percent, respectively, of the samples taken in the pocket and open water in Lay Impoundment. No gar were taken, although a number were observed passing through the treated areas.

Discussion:

Types of Technical Programs That Should Be Undertaken at Future Southeastern Meetings

Leader:

Dean A. Rosebery
Virginia Polytechnic Institute
Blacksburg, Virginia

This discussion centered largely around the question of whether or not future sessions should consist of formal or informal presentations. The concensus seemed to be that future meetings should continue to avoid formal papers, to emphasize informal discussions led by members with experience in the subject under discussion, and to arrange field inspection of fish management activities in the host State, where possible. Among the topics suggested for discussion at next year's meeting were: management of streams and public fishing lakes, re-evaluation of fish hatcheries, and commercial fishing problems.

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